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RETURN TO 207 MARKET ... ELECTRIC DEPT. NEWARK, N. J.

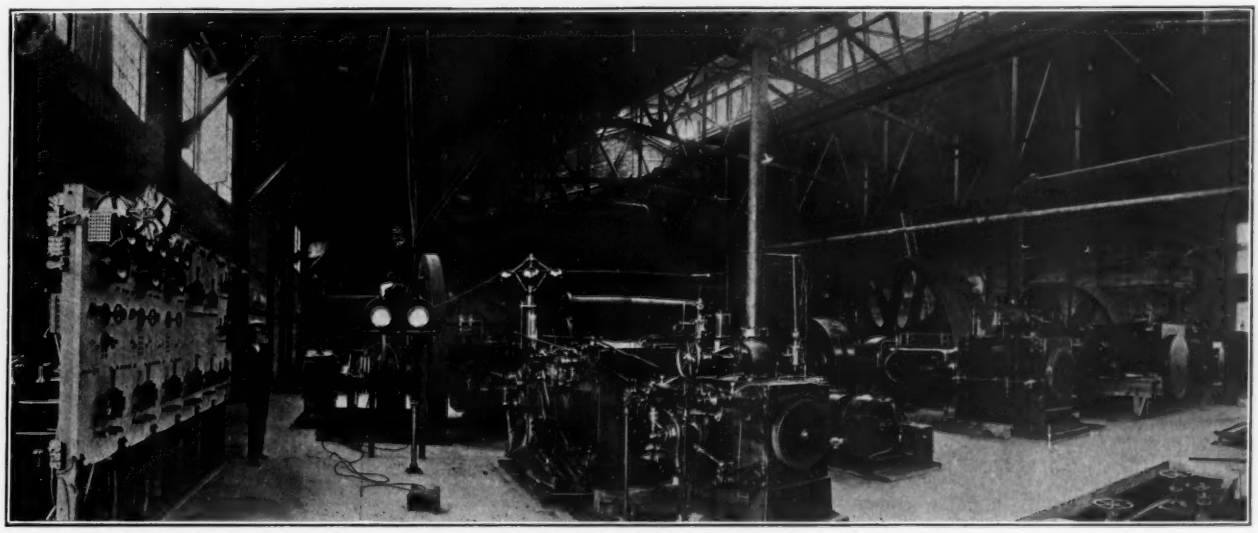
Power Plant of the Bath Portland Cement Works

A Modern 2500 Barrel Cement Plant, Located at Bath, Pa.

Of the thousands of cement plants which have been built in this country and which are now running day and night to supply the enormous demand for cement, there is not one which is not striving to turn out the best cement, at the least cost. The saving of a few cents a barrel on the cost of production amounts in a short time to thousands of dollars, even in small plants, and when the demand for cement lessens, the plant which has the best facilities for turning out standard cement is the plant that can survive the longest.

One of the latest and most improved Portland cement plants, which has been running about six months, is the Bath Portland Cement Works, located about one mile from Bath, Pa., and which has a capacity of 2500 barrels a day. The works consist of a relatively compact group of concrete and steel buildings and are arranged for a further increase in the output. It is built upon four acres of ground, below a hill slope which, with the exception of a thin layer of soil is entirely composed of cement rock, carrying approximately the correct proportions for a Portland cement. The plant also includes 320 acres of ground upon which is a plentiful supply of limestone for mixture with the cement rock.

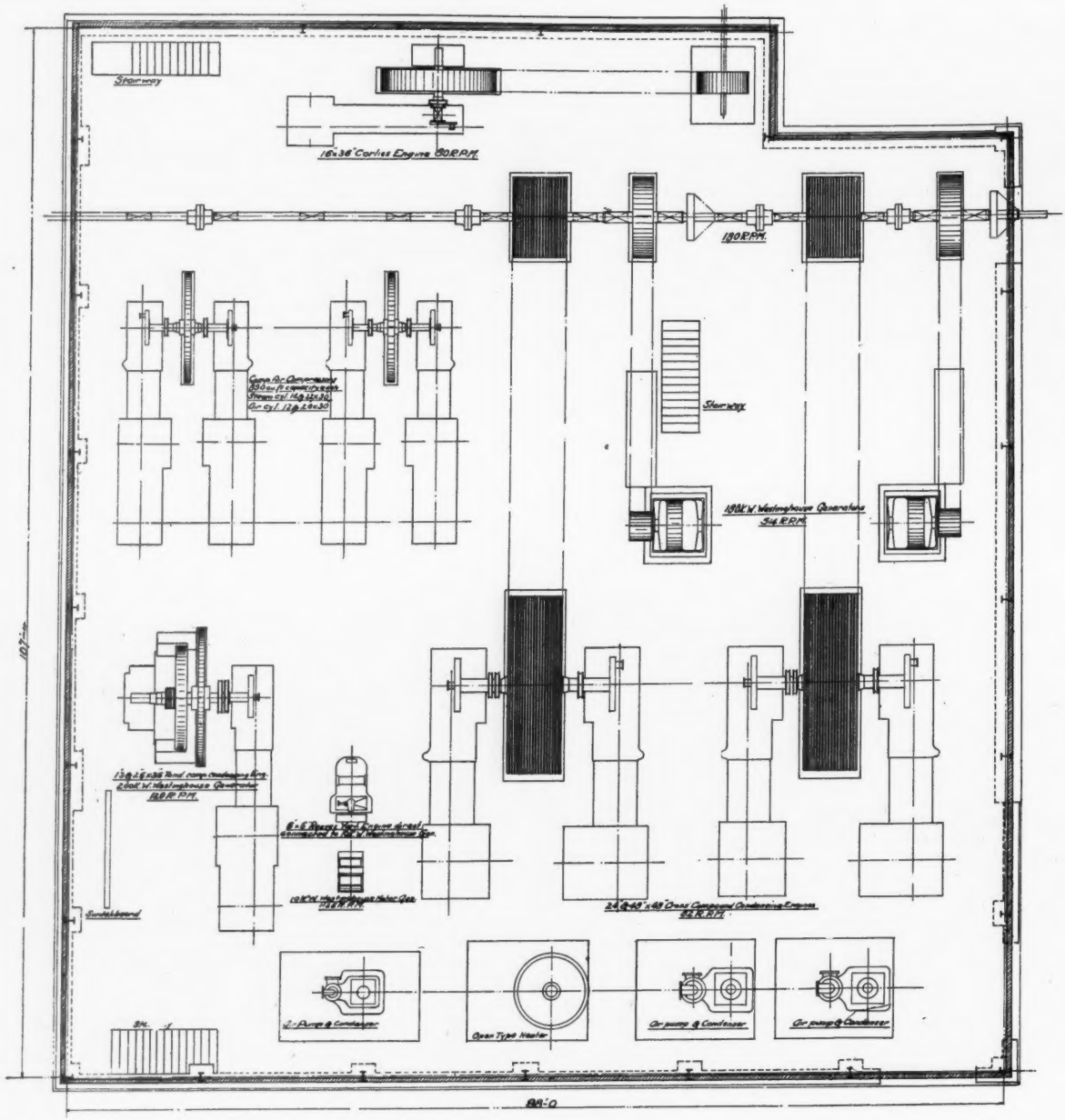
The power plant is a conspicuous part of the works, thoroughly equipped and having sufficient power to allow the increasing of the output. The power house is built 10 feet above ground level, the lower part of which is used as a basement for the steam and air pipes, condensers, cables, etc. The other buildings of the plant are built around the power house. On the west is the stone house and raw grinding room. The kiln room connects with the raw grinding room and extends south. On the east is the clinker grinding room, which forms part of the north side of the kiln house which extends south from the power house and the stock house also connects to clinker grinding room. The coal house is situated some distance from the kiln building and is connected to it by a bridge. A detached boiler house, store house, machine and cooper shop complete the colony of buildings.



General View of the Engine Room at the Bath Portland Cement Works

The cement rock from the quarry is hauled in cars, the tracks being so arranged that both the loaded cars and un-

loaded cars run by gravity. The cars enter the stone house and dump the materials into two gyratory crushers, where the material is reduced to 2½ inches and under. From each crusher the rock is delivered to a continuous bucket elevator, which elevates to a small hopper before delivering into two large crushing rolls, where the rock is crushed to ¾-inch and the grinding mills. The storage bin is of concrete and steel construction and is designed to hold 2700 tons of crushed stone. The stone is taken from this bin by a Scandinavian belt conveyor and delivers into an elevator, which delivers into a belt conveyor over bins in the raw mill. All machinery in this stone house is driven direct from the main line shaft, which in



Plan of Engine Room, Bath Portland Cement Co.

under. From these rolls it is elevated on another continuous bucket elevator and delivered into two stone dryers, 72" diameter, 55 feet long, where the stone is dried, an exhauster being used in connection with the dryers.

From the dryers, the stone discharges into a continuous bucket elevator and delivers either into a stone storage bin or into a reversible belt conveyor, which travels over the top of the stone storage bin and discharges into 8 storage bins above turn is driven by rope drives from engines in engine room.

The raw mill contains 8 3-roll Griffin mills and is located on the other side of the power house from the stone house. These mills are driven by the same main line shaft that operates the stone house. This line shaft is 390 feet long and each individual piece of apparatus driven from it has its own clutch by means of which it can be thrown in or out of service.

After the material has passed through the Griffin mills, in

the raw grinding room, it is delivered into a screw conveyor, which in turn delivers into an elevator in kiln building. This building is quite roomy and contains 6 rotary kilns, which are 100 feet long, 7 feet 6 inches in diameter at large end and 5 feet 6 inches in diameter at stack end. The stacks for these kilns are 5 feet in diameter and 60 feet high and are the largest

Compound Wetherill Air Compressors at the Bath Portland Cement Works

now in use in any cement plant in this country. These kilns are driven from the main line shaft and extend underneath the shaft. Each kiln is driven from this shaft by a Mosser speed regulator of the double-interlacing cone pattern, which also controls the feed of the raw material from the storage bins.

The raw material is elevated by an elevator receiving the ground material from the raw mill to a screw travelling transversely across the kiln storage bins. Another screw is used to take the spill and dust from the dust chambers at the feed end of kilns and delivers it back into same elevator which receives raw material from the raw mill. At the delivery end of the kiln, the clinker discharges into a pit and forms its own chute and delivers into three bucket elevators, one elevator being used for two kilns. The clinker is then elevated and delivered into three clinker coolers, 10 feet in diameter and 40 feet high, which are arranged with spouts so that they deliver into conveying machinery, which conveys it to the clinker storage where the clinker is seasoned before it is ground.

From the clinker storage, the material is delivered into an automatic measuring device which is so arranged that there will be a continued flow of gypsum entering the clinker before being crushed, from which it goes into three pot crushers. From the pot crushers, the clinker is delivered on a belt conveyor which enters the clinker grinding room and delivers the material into a bucket elevator, which in turn delivers into two sets of clinker crushing rolls. Here the clinker is ground to proper fineness, and after passing through these rolls is elevated and delivered into a screw conveyor which dumps it into large storage bins. Thirty Griffin mills are used to grind the clinker. The clinker falls directly from bins into hoppers of mills, where it is ground to finished cement. Two screw conveyors take the finished material to cement stock house. All the machinery in this building is connected to the main line shaft, which is driven by rope drive from the engine room.

The coal pulverizing plant consists of two 3-roll Griffin mills. Coal from cars on a high trestle outside the building is dumped and elevated to a coal dryer. From the coal dryer it is delivered by a screw conveyor into a crushing roll and from there is carried overhead into the storage bins for the 3-roll mills. From the mills, the pulverized coal is conveyed by means of conveyors to coal bins in front of kilns. A motor is installed at one end of this building for driving the machinery and is enclosed by steel and concrete, the same construction as the coal house, which is entirely fireproof.

The power for driving the plant is generated in the boiler house, which contains eight 300 horse power Berry boilers. These boilers are the invention of William H. Berry, of the Berry Engineering Co., who was recently elected State Treasurer of Pennsylvania, upon a strictly independent ticket. Bituminous coal is used for fuel which is delivered on a trestle 12 feet high, 45 degree coal chutes delivering the coal in boiler room. The boilers at the present time are hand-fired but the fronts are so arranged that they can be equipped with automatic stokers. A brick stack 175 feet high is located centrally in building, 4 boilers being on each side of stack. Each boiler is 10 feet 6¼ inches outside diameter and 20 feet 9½ inches high. They contain 2-inch horizontal tubes and 4-inch circulating tubes made of steel. The outside casings are lined with asbestos blocks and are provided with doors for inspection, the whole casing revolving on rollers. Each boiler is fitted with two 3½-inch pop-safety valves, a Reliance water column, self-closing gauge cocks, stop and check valves and three blow-off cocks. The working pressure of the boilers is 150 pounds. Two horizontal 14″ x 8½″ x 10″ duplex feed pumps supply water to the boilers through a 2000 horse

One-Half of Boiler Room showing four 300 H. P. Berry Boilers

power open feed-water heater. A fire pump is also so connected that it can be used for boiler feed in cases of emergency. Two Metropolitan injectors are also installed.

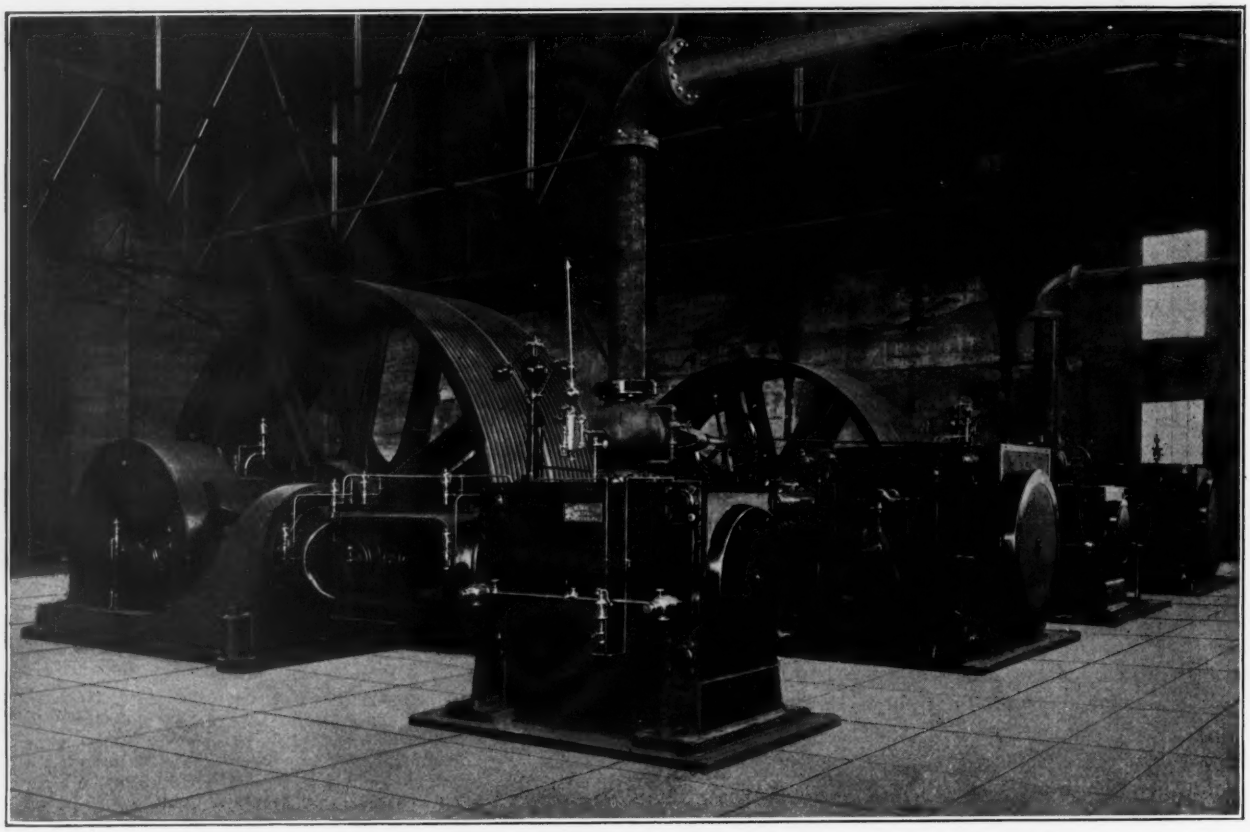
The engine room contains two 1100 horse power cross-compound condensing engines, side by side, one engine being employed to drive the raw mill department, while the other drives the clinker department. These engines are of the Wetherill

heavy-duty Corliss type and have cylinders 24 inches and 48 inches by 48 inches. They are each fitted with a rope fly-wheel, 18 feet in diameter and 67¾ inches face, weighing 100,000 pounds, which drives twenty-two 2-inch transmission ropes. These ropes in turn are connected to rope pulleys on the main line shaft.

Alongside of the large engines is a 300 horse power tandem compound Wetherill-Corliss condensing engine, directly connected to a 200 kilowatt alternating-current generator. The cylinders of this engine are 13 inches and 26 inches by 36 inches, and the generator is of the Westinghouse type and when running at 120 revolutions per minute generates three-phase alternating-current at 440 volts. This generator is used as a reserve for helping out the two other generators which run belted from the main line shaft driven from the larger engines.

the action of the regular engine governor, so that the speed of the engine may vary automatically in proportion to the amount of air used. The inter-coolers, which are mounted above the air cylinders, are made up of 18-inch wrought-iron pipes containing tube heads of brass and brass tubes 1 inch outside diameter. Each cooler has 210 square feet of cooler surface, the water flowing through the inside of the tubes with the air on the outside.

A simple Wetherill-Corliss engine, 16 inches by 36 inches, is held in reserve in case any accident should happen to the motor which drives the kilns. This engine is equipped with a belt wheel 12 feet in diameter, 27-inch face, weighing 13,000 pounds and runs at 80 revolutions per minute under a pressure of 100 pounds, the steam for which is obtained through a reducing valve.



1100 H. P. Cross Compound Wetherill Corliss Engines equipped with Rope Drivers at the Bath Portland Cement Works

A short distance from this engine are located the two Wetherill air compressors. They are of the Wetherill cross-compound condensing type with the air cylinders equipped tandem with the steam cylinders. The steam cylinders are 13 inches and 22 inches by 30 inches and the air cylinders are 12 inches and 20 inches by 30 inches. Each compressor has a capacity of 900 cubic feet of free air per minute when running at a speed of 80 revolutions per minute, steam pressure 140 pounds, air pressure 110 pounds. The compressed air is used for injecting coal into kilns, for drilling purposes, for the three artesian wells and for blowing dust out of motors. The air compressor cylinders are water jacketed and the speed of the machines is regulated by an air regulator operated by air pressure, which controls the steam cut-off independent of

On the engine room floor is also located two Westinghouse belted generators of 180 kilowatt capacity, each of which is used for driving the motors throughout the buildings. They run at 514 revolutions per minute and generate 440 volt, 3-phase, 60-cycle current. A motor-generator of 10 kilowatts capacity, running at 1120 revolutions, is used for transforming the 440 volt alternating-current into 125 volt direct-current for the lighting main and for exciting the fields of the alternator. In case anything should happen to this generator or the large engines are not running, a 6 x 6 Reeves engine directly-connected to a 10 kilowatt 125 volt direct-current generator is used for supplying lights and exciting the alternating-current generator.

The three large engines are equipped with the gravity oiling

system. An oil tank overhead supplies all the main bearings with oil, which is caught below the engine room floor, filtered and returned to the overhead tank by a 3″ x 2″ x 3″ duplex Dean oil pump. The large engines are also equipped with the Monarch stop system, by means of which the engines are stopped automatically if they exceed two revolutions above the normal, or in case of accident, by pushing a button in any part of the engine room, the engines can be stopped.

The two large engines are each supplied with their individual condensing apparatus, while the air compressors and tandem compound engine make use of a third condensing set. Jet condensers of the Dean Bros. vertical pattern are used, the pumps for the larger sets having cylinders 18″ x 40″ x 24″ and for the small set 12″ x 28″ x 18″. The condensing water is obtained from a reservoir located within 50 feet of the power house. The reservoir has a capacity of 3,500,000 gallons and it is so arranged that the water must circualte the entire distance of the reservoir after being discharged from the condensers before it is used again, thus acting as a cooling pond.

The motors used throughout the buildings are all of the three-phase 60-cycle 400-volt Westinghouse induction type. One 200 horse power motor running at 580 revolutions per minute is used in the coal house for running the coal dryers, Griffin mills, three elevators and three screw conveyors. One 100 horse power motor running at 580 revolutions per minute is used to drive the line shafting which rotates the kilns. The 16″ x 36″ simple engine in engine room is used as a reserve in case of accident to this motor. One 100 horse power motor is used to drive the stock machinery, which consists of bagging and barreling machinery, and for driving conveyors. A third 100 horse power motor is used to drive the crushing rolls which crush the cement rock and limestone one-half inch and finer. One 30 horse power motor is used for driving the bucket elevators which carry the clinker from the discharge of the kilns to coolers on outside of building. Two 10 horse power motors are used, one for driving machine shop where repairs are made and one for lifting empty cement rock cars to gravity road. Six 1 horse power motors, running at 1120 revolutions, are used at the kilns for conveying coal from bins and delivering into the pipe, where it is mixed with air and blown into the kilns for fuel.

The switchboard contains seven panels of blue Vermont marble on which are mounted the usual ammeters, voltmeters, wattmeters and synchronoscope. The switches are so arranged that the lighting feed bus-bars can be thrown from the direct-current exciter set bus-bars to the low voltage alternating-current bus-bars. The motor panels are so wired that the motor feed lines can be thrown on either one of two sets of 3-phase bus-bars.

The entire plant was designed and constructed under the supervision of Frederick B. Franks, who is superintendent and chief mechanical engineer of the plant, aided by James A. Gish, Jr., assistant mechanical engineer. Mr. Wm. H. Motsen is chief engineer of motive power. The boilers, air compressors, Corliss engines and most of the cement machinery were furnished by Robert Wetherill & Co., Incorporated, Chester, Pa.

A STUDY OF PLAN $\div$ 33000

By Chas. J. Mason.

To the operating steam engineer who is inclined to be studious and who more or less dabbles with figures, the $\frac{\text{PLAN}}{33{,}000}$ horse power formula most frequently occurs, and is used, perhaps, more than any other formula by him. Yet for all this, and the fact that every issue of every steam engineering journal contains something directly or indirectly relating to it, comparatively few really understand it, and know what can be done with it. To derive the most benefit from the use of a formula, it is necessary that the construction of the formula be understood; why it contains so and so many factors, what these factors stand for, why they are arranged as they are, and finally, how the factors may be transposed to give a desired result.

A formula is a short method of expressing a rule. By employing symbols to represent certain quantities a long worded rule may be dispensed with. The eye becomes accustomed to taking in at a glance just what is meant and required when looking at a formula, and besides that, it is far easier to remember the position of letters in a certain formula, than it is to remember the equivalent worded rule. The formula—aside from its significance—remains engraved upon the mind, whereas the words of a rule might easily be forgotten. When occasion arises to use the formula it becomes an easy matter to transfer it from the mind to a pad of paper, when the significance of the various factors becomes apparent, even if it were temporarily forgotten.

Now, everyone will agree that it is not difficult to remember the word PLAN, nor is there much more mental effort required when it is written over the figures 33,000 like this $\frac{\text{PLAN}}{33{,}000}$. Further, it does not require much effort to remember that each letter stands for some value which will be expressed in figures, and that all the values which the letters represent are to be multiplied together, and the product of such multiplication is to be divided by the figures below the line in the formula. As it is desired to have a formula as compact as possible, the multiplication sign $\times$ is not placed between the letters, but it is to be understood to be there, and when the actual operations are performed of course the process as represented by the sign $\times$ is gone through with. It should also be understood and remembered that the process of division is signified by the line between the letters and the numerals. So much for the formula itself. The result of the processes of multiplication and division of the formula which we are considering, or the quotient obtained is a figure or figures which represent the indicated horse power of the engine, to the dimensions of which the formula has been applied.

From the foregoing it will be seen what the formula in question is, what the symbols are and how they are placed,

how they are to be dealt with arithmetically, and what result is produced by the arithmetical processes employed. First of all, then, let the student reader digest what has been stated so far, and train himself to remember it. When he has carefully read what has been stated, he will find, that because of the presence of the formula, it will not be necessary for him to commit to memory the statements, for the formula itself will always suggest what has been stated about it, and form a connecting link, so to speak; therefore all that is necessary is to remember the formula when it is required for use. This, as I said before, is quite easy to do, particularly with regard to the formula in question because of its simple construction.

Next let us consider what the letters P L A N stand for, and what numerals are to take their places. The placing of numbers for the letters is called substituting. The letter P stands for the mean effective pressure per square inch acting on the piston of the engine to push it forward and backward alternately. Sometimes this is understood to mean the average boiler pressure, by some readers, but this understanding is not correct, as there is quite a difference between the meaning of the two terms. To discuss the points of difference in their fullness would necessitate us taking up a side issue which is not the intention of this article. Sufficient it is for us to say that the mean effective pressure is found from an indicator diagram, or by calculation, some of which employ constants which simplifies the operation. As before stated, a study of the difference between boiler pressures and mean effective pressures, and how the latter are found exactly, is not immediately concerned in this article. When the mean effective pressure is found—in any given case—it is substituted for P in the formula.

The letter L stands for length of stroke of piston expressed in feet. Note particularly the phrase *expressed in feet,* as it is of the greatest importance to remember that the stroke must be stated in feet or decimals of a foot, and not in inches, in the formula. For example, if an engine has a stroke of 12 inches, L in the formula becomes 1, because 12 inches equals 1foot. If the stroke were 9 inches, then the decimal equivalent of 9 inches, .75 ft. would be substituted in the formula. Or, it could be stated like this: $\frac{9}{12}$, as 9 inches is nine-twelfths of one foot. Again, suppose the stroke is 18 inches, then substitute 1.5 as 18 inches is one and one-half foot. As in the other case it can be stated $\frac{18}{12}$ — which, of course, reduces it to feet. In short, a good form to remember when substituting for L is to make it a fraction whose denominator is always 12, as illustrated above. This does away with the working out of decimal places and really saves time in the calculation.

Now, the reason that L must be expressed in feet instead of in inches is this: Horse power is measured in foot-pounds of work per minute, the standard being 33,000. This also explains the presence of the constant 33,000 is the formula. The simplest definition for this constant is, that one horse power is equivalent to raising 33,000 pounds 1 foot high in 1 minute, or we can state it like this: 1 pound raised through 33,000 feet in 1 minute, which, as far as results are concerned, is the same. The force in pounds times the space in feet through which the force acts equals the number of foot pounds of work accomplished. This explains why L in the formula must be in feet, for the product of PL or $P \times L$ is equivalent to the product of force in pounds and space in feet; P, or mean effective pressure, representing force, and L the stroke in feet representing the space passed through. If the reader carefully considers the foregoing, he will never make the mistake of substituting the stroke in inches.

We now come to the letter A which stands for the area of the piston in square inches, against which the mean effective pressure acts. Note the expression square inches, it is not square feet. The calculation employs square inches because the unit of pressure is given in square inches; so that it is so many pounds per square inch acting on so many square inches of surface. The area of the piston is found by multiplying the diameter in inches by itself, and that product by the constant .7854. Or, expressed in formula:

$$D^{2''} \times .7854 = \text{area in inches.}$$

Strictly speaking, the area of the piston rod should be taken into consideration, and the proper deduction made because of it. Ordinarily this deduction is not made, because for practical purposes the result is not materially affected.

Occasionally we find the value of letter N misunderstood by the reader. Some think it refers to the number of revolutions which the shaft is turning per minute. It is in fact the number of strokes of the piston per minute, and as there are two working strokes (unless a single acting engine should be under consideration when using the formula, then there is *one* working stroke during one revolution, and N is equal to the number of revolutions per minute) during one revolution N equals the revolutions per minute times 2. Thus, if a double acting engine runs 75 revolutions per minute, $N = 75 \times 2 = 150$; but if it were a single acting engine, $N = 75$. An engine is presumed to be double acting, unless otherwise stated. The presence of 33,000 has already been explained.

All the factors above the line in the formula are simply an expression of force acting through space in a given time, which is, in other words, foot-pounds of work done per minute. It necessarily follows that because 33,000 foot-pounds of work per minute is the horse power standard, as many times as that constant is contained in the result of the continued product of the factors above the line, just as many horse power will the quotient represent.

A study of the formula shows, that by increasing the value of any of the factors above the line, the quotient, which is the indicated horse power, will also be increased, because the constant 33,000 is never increased nor reduced. Likewise, if any one or more factors above the line be reduced in value the horse power will also be reduced. When it is customary to take indicator diagrams from an engine periodically, in order to determine just how the values are with regard to correct setting for good steam distribution, and also to calculate the mean effective pressure for the purpose of discovering the power developed, then, what is called the horse power constant is brought into play.

The horse power constant of an engine whose speed does not change is found by applying the formula to the known data of the engine, and for the factor P substitute the numeral 1. This as can easily be seen, will give the horse power of the engine for 1 pound mean effective pressure. This number so

found can be noted down or remembered and when the mean effective pressure of any card is multiplied by the constant, the horse power as indicated by the card is found at once, without having to go through the complete calculation. Should the speed of the engine vary at different times, then the constant will be calculated from the known data of the engine which cannot change, as L and A, and of course 33,000, and for P and N substitute the numeral 1. Then, to find the horse power, simply multiply the constant so found, by the product of the mean effective pressure and the number of strokes per minute at which the piston was running at the time the diagram was taken.

As $\frac{PLAN}{33{,}000} = $ I. H. P., it can be seen by inspection and by trial that if all the factors except one be given, the unknown factor may be found by the simple process of arithmetic as employed to find the I. H. P. which was in that case the unknown factor of the complete expression. It has already been explained how the I. H. P. factor is found, and this is about the extent to which most engineers employ the formula. So far, so good; but it may be convenient if not absolutely necessary to know how to transpose the terms of the formula so that any factor other than the I. H. P. may be found.

Suppose, for instance, that the stroke of an engine be given, the diameter of the cylinder, the number of revolutions per minute, and the indicated horse power (I. H. P.) and it is required to learn just what the mean effective pressure was at the time the given horse power was developed. The way to find this is to multiply the constant 33,000 by the given indicated horse power, and divide the result by the product of the stroke in feet, area of piston, and number of strokes per minute. This expressed in formula would be:

$$\frac{33{,}000 \times \text{I. H. P.}}{LAN} = \text{P (M. E. P.)}$$

The same would apply for any factor *above* the line which may be required to be found. If the diameter of the cylinder is required to be found, it would just be necessary to find A of the formula as just explained; and then from the area find the diameter by dividing the area by .7854 and extracting the square root of the quotient. This expressed in formula is $\sqrt{\frac{\text{area}}{.7854}}$. If the reader does not understand how to extract the square root of a number, he will then have to use a table of square and cube roots which may be found in most engineers' pocketbooks. Let me say right here, that no steam engineer should be without a pocketbook such as Kent's, which contains various tables and lots of information such as all engineers frequently require.

It may not at first be quite clear to the reader why the transposition which I have just described is correct, and how its correctness may be established. Probably the simplest way to demonstrate it is to take a set of easy numbers, which when arranged can be seen at a glance without actually going into calculations. For example, $\frac{6}{2} = 3$. Here it can be seen that $2 \times 3 = 6$, and the same method would apply no matter how many figures there were alongside the 6. Likewise, if the number 2 were unknown and required to be found, it can be readily seen that by dividing 6 by the 3, 2 will be the quotient, or $\frac{6}{3} = 2$. Now, referring those simple examples to our formula, we have:

(1) $\frac{6}{2} = 3$. Illustrating $\frac{PLAN}{33{,}000} = \text{I. H. P.}$

(2) $2 \times 3 = 6$. Illustrating $\frac{33{,}000 \times \text{I. H. P.}}{LAN} = \text{P.}$

(LAN can be found the same way.)

(3) $\frac{6}{3} = 2$. Illustrating $\frac{PLAN}{\text{I. H. P.}} = 33{,}000.$

Of course, method (3) would never be required in practice for as before stated 33,000 is a constant and never is required to be found, but the method is given to show how it could be found if desired.

To put in practice what is contained in this article the reader has simply to—first, remember the formula; secondly, write it down and then remember what the various letters stand for; thirdly, in any given question to which the formula is to be applied, substitute the known figures of the question in their respective places in the formula, and proceed with the arithmetical calculations according to the instructions contained in this article.

Let the interested reader (who is not already familiar with the substance of this article) work out a problem, and experiment with it along the lines suggested, and he will be astonished at how soon he will understand the operations, and how easy they are to remember.

The well informed will find nothing new in what I have written here. The article is not written for such, but for those whose opportunities are limited, and who require simple and clear explanations of whatever subject may be discussed.

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Air Compressor Valves.

As the first requirement of an air compressor is to get the free air into the cylinder, the most important of the air valves are the inlet valves on the low-pressure or intake cylinder. Good inlet valves should permit of very large passages leading to them, so that the free air will reach the valves without friction. The port openings should also be large, so that but little suction will be required to draw the air into the cylinder. The air should also be taken into the cylinder before it gets heated, for the heating of the intake air is a source of loss that is quite important; for every five degrees that the air is heated before compression means a loss of one per cent. in capacity and a waste of one per cent. in power. Inlet valves should also close promptly when the crank passes the centre, otherwise some of the air will escape before compression begins. When closed, the inlet valves should not leak, as leakage will materially reduce the capacity of the compressor. Clearance also causes a reduction of capacity and should be kept low, but it is not nearly so important as the heating of the intake air or leakage.

COMPRESSION IN A STEAM CYLINDER

By W. H. Wakeman.

As a rule, men in charge of steam plants understand the meaning of the term "compression" as used in steam engineering, and appreciate the value of it, too, but occasionally we find an exception to the general rule.

Owners of steam plants are not expected to be especially interested in such matters, as they hire engineers to run their plants, and pay them for both theoretical and practical knowledge along these lines, but there are exceptions to this rule, also, for sometimes the proprietor of a factory or shop is very much interested in this department, and wishes to have it appear equal to or better than any other part of the establishment.

Frequently, such men read articles on steam engineering in the mechanical papers with as much intelligence and interest as men who handle the throttle valve and attend to the numerous duties that must be discharged by the modern steam engineer who expects to hold his situation and give satisfactory returns for the salary paid him.

This article was written for engineers and steam users, regardless of their knowledge on the subject, or opinion concerning the same, because the term is frequently misunderstood or misapplied, and when the value of it is discussed there is something to be said on both sides of the question.

It is necessary to explain the meaning of the term "cushion" first, because many readers get the two terms so hopelessly mixed when talking on the subject, that it leads to misunderstandings which detract from the value of discussions along this line that would otherwise be both interesting and instructive.

An engine is cushioned by live steam and the operation will be readily understood by examination of Fig. 1, which represents the valves, cylinder and piston of a Corliss engine. This type of engine is selected because it is more easily understood than any other kind, except the Greene or some other kind which is fitted with four separate valves.

The piston is traveling in the direction indicated by the arrow, hence the supply of steam has been cut off by the crank end steam valve (as it is now closed), pressure is reduced and motion is maintained by momentum of the fly-wheel and other moving parts.

As shown in the illustration, the head end exhaust valve is just closed, because the cut is intended to answer a double purpose, but we may assume that this valve remains open until the piston has nearly reached the end of its stroke, when it is quickly closed, and the steam valve above it is opened at the same time.

Space between the piston and cylinder head is thus filled with live steam, against which the piston strikes (to use a common expression), as if it was a cushion, thereby arresting its momentum without shock or jar.

At this point I wish to remark that when adjusting these valves, care must be taken to close the exhaust valve before the steam valve opens, as otherwise much heat will be lost by blowing steam directly through the clearance into the exhaust chest.

If the steam valve is given too much lead, excessive cushion is the result, also unnecessary friction or lost work, because this steam tends to resist the piston as it advances, although the crank is now so near the centre that this resistance is not so effective as it would be earlier in the stroke.

A reasonable amount of compression is not objectionable, but is beneficial, because it eliminates shocks and jars, at the same time assuring a full supply of steam at the beginning of the following stroke.

For the purpose of illustrating the term "compression," we may take Fig. 1 just as found. Inasmuch as the piston is traveling in the direction indicated by the arrow, the head end steam valve is closed, and remains motionless during the time under consideration.

The exhaust valve below it is also closed, but is still in motion because it is always connected to the wrist plate. The top of this valve is traveling in the same direction as the piston, therefore its lap is increased and the port remains closed until the next stroke is nearly completed.

As this engine is running at full speed, steam at a low pressure fills the space between piston and cylinder head. Assuming this to be a non-condensing engine exhausting into the air, this steam is of no value while the piston occupies the position shown; therefore if it can be utilized, the result will be an advantage.

Suppose that as the piston now stands, it is 12 inches distant from the cylinder head, and the space is filled with steam at no pressure by the gauge, or say 15 pounds absolute.

When the piston is 6 inches from the cylinder head, the pressure is 30 pounds. At 3 inches it is 60 and at 1.5 inches 120 pounds or 105 pounds by the gauge. This is according to Mariotte's law for the compression of gauges, and although we cannot expect to secure the exact result that it calls for under ordinary conditions, yet it is quite possible to get the above-mentioned pressure, when the end of stroke is reached; therefore, it is not unreasonable to use it for illustration.

Enthusiastic advocates of the Corliss valve have claimed that in case of water accumulating in the cylinder, it will rise and discharge it back into the steam chest before any of the parts are damaged, but there is much chance for doubting it for the following reason: Steam chest pressure acts on the whole upper surface of valve to hold it to its seat, as follows: If the valve is 3 inches wide and 22 inches long, there are 66 square inches exposed to pressure.

Suppose that with 80 pounds boiler pressure, 75 by the gauge, or 90 pounds absolute are realized in the cylinder. The total pressure acting to hold the valve down is $66 \times 90 = 5940$ pounds. Assuming the port to be 1.5 inches wide and 20 inches long, there will be 30 square inches exposed to compression pressure, or a total of $30 \times 120 = 3600$ pounds. As this represents a difference of 2340 pounds, it shows why the valve does not readily lift from its seat.

The total downward pressure is 5940 pounds and there are 30 square inches exposed to compression pressure, therefore it requires $5940 \div 30 = 198$ pounds to the square inch to balance the valve, and, of course, this must be exceeded in order to raise it and let water out.

Another point to be considered is that if this water is put

back into the steam chest, it will be returned to the cylinder at the next stroke, therefore it is not disposed of. Engine builders recognize this fact and put relief valves on their Corliss engines, especially if they are to be run at high speed.

The above description presents a fact that is doubted by some engineers, as they do not believe it possible to raise compression above steam chest pressure, yet it is easily done.

Due examination of the illustration shows that during this operation there is no connection between the cylinder and the steam chest, hence pressure in one has no effect whatever in the other.

If we have 90 pounds absolute pressure in the steam chest and 120 pounds compression, the latter exceeds the former by 30 pounds, and if we take gauge pressure in both cases, the difference is the same; therefore when the steam valve opens to give the required lead, steam passes from the cylinder back into the steam chest. Indicator diagrams taken under these conditions plainly show this action, for pressure rises as above explained, then falls when the steam valve opens.

It cannot be successfully claimed that this fall of pressure is due to increase of space caused by the piston advancing, because it has not yet begun to travel in the opposite direction.

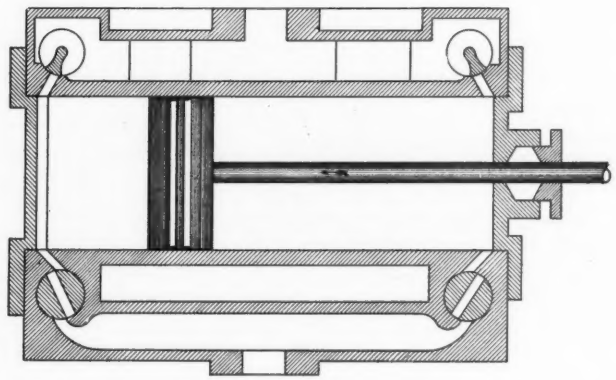


Fig. 1

Having followed the action of engine parts which cause compression, it is next in order to consider its effect in everyday practice. Where there is absolutely no compression, the clearance must be filled by live steam, twice for each revolution of the fly-wheel. Superficial consideration of the matter leads to the conclusion that if the clearance is filled with exhaust steam as above described, much coal will be saved by the change, but this expectation is not realized when the matter is tested, for the simple reason that the process of compressing this steam absorbs as much power as it gives out after the motion of piston is reversed, consequently it is about as well to use live steam for this purpose, so far as economy of steam is concerned, but compression is of great value in modern steam engineering, on another account which is well worthy of consideration.

Again referring to Fig. 1 and taking into consideration the position now occupied by the piston rod, crosshead and connecting rod, it will be noted that these parts are traveling at a high rate of speed, consequently their momentum is great. This is partly due to what is known as "angularity of the connecting rod."

As the crank nears the inside centre, this speed is reduced and is brought down to zero when the centre is reached. As this action eliminates the momentum above-mentioned, it brings stress to bear on the crank pin, provided the valves are set so that there is neither cushion nor compression in the cylinder.

I am well aware of the claim made by some engineers to the effect that when the piston reaches the end of a stroke there is no momentum left, but this is a mistake. Of course, the gradual reduction of speed from the position in which the piston is shown, reduces the momentum before the end is reached, but does not entirely eliminate it. Furthermore, if this claim was true it would not free the crank pin from excessive load, because the momentum must still be absorbed by this pin regardless of the exact time in which it is done.

Passing on to consideration of the effect of compression on the moving parts mentioned, it will be noted that as the speed of piston is reduced, the pressure in front of it is increased. This results in bringing the reciprocating parts gradually to a state of momentary rest, causing them to be reversed quietly, without extra strain on the crank pin.

I saw a very good illustration of this action a few days ago. An engine in a certain mill was carrying a heavy load, yet was making but little noise, although the engineer assured me that there was much lost motion in both crank pin and wrist pin boxes that he could not remove until the boxes were planed off, as they had been keyed up until their inner ends were in close contact.

After this engine was shut down at night I placed my hand on each of these boxes in turn, while the engineer admitted steam quickly to one end of the cylinder, but before enough pressure to move the piston accumulated, he reversed the valve gear and admitted steam to the other end.

I will not attempt to state how much lost motion there was in these boxes, but am fully justified in saying that it was excessive in both places. Had there been no compression in the cylinder the engine would have pounded badly.

Several years ago I visited a friend who had charge of a Woodruff and Beach engine, that was practically noiseless, except what was caused by the valve gear. Indicator diagrams from this engine showed it had no compression whatever, and in addition to this defect in valve setting, it had no lead, for the piston traveled several inches before the steam valve opened.

Owing to these conditions, the crank pin required more lubrication than it otherwise would have needed. It was fitted with an old-fashioned oiler that traveled with the pin, as stationary crank pin oilers were scarce at that time. I have seen the engineer unscrew this oiler, fill it and screw it into place while the engine was running full speed; therefore it will be readily understood that the speed was not high.

Absence of a heavy pound at the end of each stroke was due to this slow speed, and a very close adjustment of both crank pin and wrist pin boxes. This close adjustment is objectionable because it is almost sure to cause trouble if for any reason the pins are not lubricated perfectly during every revolution.

These two engines represent extremes that it is well to avoid, so far as the adjustment of boxes is concerned. Boxes that are loose enough to permit oil or grease to freely enter between the surfaces to be lubricated, give best results when run in connection with a reasonable amount of compression.

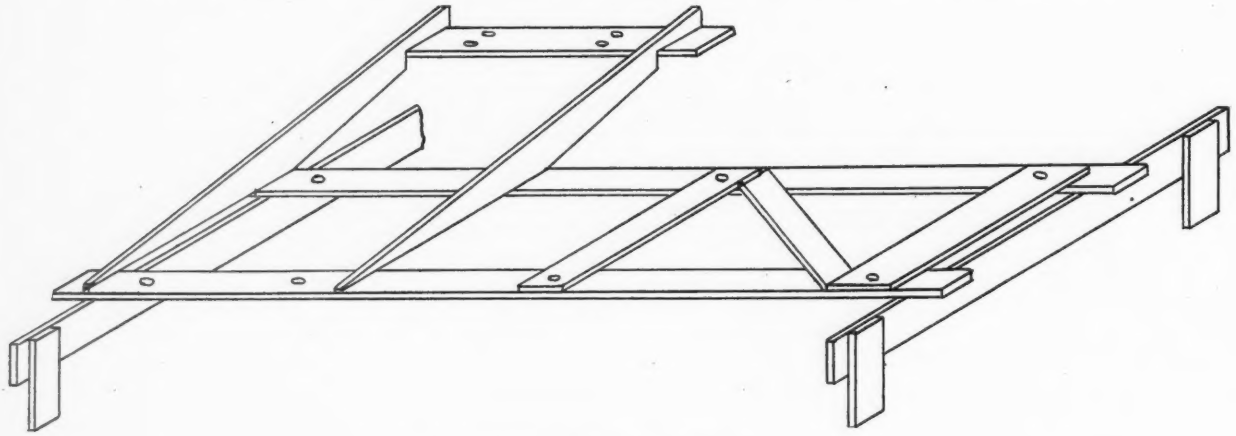
(TO BE CONTINUED)

FOUNDATIONS FOR ENGINES

Precautions Necessary to Make a Good Foundation

When a new engine is purchased, the specifications invariably require that the foundations of the engine shall be supplied by the purchaser of the engine and it is usually up to the engineer in charge of the plant to see that it is done properly, or when an old engine is moved to another location in a plant it is usually considered that the engineer in charge will be able to supervise the work.

In case a new engine is purchased, the engine builder usually furnishes the drawings for the foundation which consists of an accurately dimensioned drawing showing the foundation in plan and one or two elevations and also a drawing of a board template which must be made before the foundation bolts can be located. A hole is bored in the template where each bolt is located and the template is supported over the place where the foundation is to be constructed at such a height that the foundation bolts can be suspended in the position they will finally occupy by passing them through the holes in the template, the nut on the upper end holding them in position. The foundation is then built around the bolts, leaving holes about them an inch or two greater in diameter than the bolts themselves. This is done so that the bolts can be moved slightly should any error occur in boring the template or in case the holes in the bed plate do not exactly match.



Template for Engine Foundation

When building a foundation for a new engine, the drawings furnished by the engine builder should be carefully followed, but in case there is no drawing to go by, the engineer must design one himself. There are several rules which must be followed in order that the foundation shall answer the functions demanded of it. The engine foundation must go deep enough below the surface to be beyond the effects which cause unequal settling, such as frost, vibrations or the proximity of other loads. The necessary depth below the surface that is desirable for an engine foundation to begin will depend upon the soil but it is usually not less than three feet for engines of any considerable size and where the ground upon which the engine is built is subjected to frost, the engine foundation should extend at least six feet below the general level.

If loose rock or poor earth is found, this should be removed and the excavation filled with concrete, in which loose stones, old bricks, etc., may be imbedded. This should be continued up to the level at which the regular brick or concrete foundations are to commence. When good loam or clay exists for some distance under the surface of the ground, the earth may be levelled off and the foundation commenced on a layer of concrete just thick enough to give a good bearing. If the soil is found to be soft and unreliable, piling is usually resorted to. Piles may be of spruce or hemlock at least 5 inches in diameter at the point and 10 inches at the butt end and should be driven into rock or hard pan if possible. The tops of the piles should then be cut off to a level and the soil excavated around them to a depth of a foot or so and a bed of concrete should be laid around and over the piles forming the concrete bed, which will be capable of distributing the load.

The weight of the engine should be distributed over a sufficient area to prevent settling. As to the bearing capacity of different soils, the New York Building Code states: "Different soils, excluding mud, at the bottom of the footings shall be deemed to safely sustain the following loads: Soft clay, one ton per square foot; ordinary clay and sand together, in layers, wet and springy, two tons per square foot; loam clay or fine sand, firm and dry, three tons per square foot; very firm, coarse sand, stiff gravel or hard clay, four tons per square foot." If solid rock is struck, there is practically no limit to the load that can be imposed upon it.

If it is found upon investigation that the character of the soil will safely bear the weight of the engine, it must also be considered that the engine foundation must have sufficient weight and mass to hold the engine firmly against any unbalanced forces due to the reciprocating parts of the engine. The weight and mass of the foundation must also be sufficient to absorb vibrations in the engines, so that they will die away in it and not be transmitted to other parts of the building.

The vibration of machinery is often a great annoyance especially in a hotel or office building and care should be taken in

building the foundation that it will be prevented. This vibration is often pronounced when the engine is built upon rock, in which case some kind of footing should be provided which will deaden the vibration and arrest its transmission. Sand, if it can be kept dry, is highly recommended for this purpose and in case rock is struck, it is advisable to dig the foundation several feet deeper than necessary and several feet wider on all sides than the foundation is to be. The sand is then filled in to the depth the foundation is to start and must be built up around the sides with sheathing so as to prevent any displacement of the sand. Asphalt, mineral wool and hair felt are also said to have been used successfully as footings because they kill any vibration in the engine before it reaches the ground.

The foundations for engines are usually made of brick laid in cement mortar or of concrete. When brick foundations are used, the cement mortar should be made of one part Portland cement to two parts clean, sharp sand. Good concrete is obtained by mixing one part good Portland cement, two parts sand and four parts broken stone, the latter small enough to pass through a 2-inch ring. Concrete should be laid in layers not over 6 inches thick and each layer should be thoroughly rammed before the next layer is put on. Such a foundation has to be surrounded with board walls so as to hold the concrete while it is being laid. A Portland cement concrete foundation ought to stand at least two months before it is loaded and a brick foundation should be allowed to stand a month in order that it should be thoroughly dried out before using. When brick is used it should be of the best quality hand burned. If appearance must be considered, the outer courses of the foundation may be laid with faced brick while the interior may be laid with the ordinary kind.

In placing the bolts in the foundation, a distributing plate is usually used on the lower end, so that the strain on the bolt may be distributed over a number of bricks and so that it will not pull through. The lower end of the bolt and the distributing plate are usually threaded so that the plate can be adjusted so as to bring it in line with a course in the masonry. To allow the bolts to be deflected sidewise, it is now general practice to surround the bolt with a piece of pipe reaching from the distributing plate to the top of the masonry and after the true position of the bolt is fixed, the space between the bolt and pipe is filled with cement.

The foundation is then ready for the bed-plate but on account of the rough tools used by masons, it is rarely found that the top of the foundation is a true plane. The bottom of the bed-plate is nearly always a true plane, so that a joint between the bed-plate and foundation must be made which will insure the bed-plate being permanently level. With large engines or particular jobs, it is usual to use a flat capstone in which holes are bored so that it can be placed over the foundation bolts. The top surface of the stone is a true plane and the stone can be so mounted on the masonry as to make a perfectly level surface for the bed to rest upon, the stone being allowed to rest upon a bedding of cement.

When the bed-plate is placed upon the foundation as finished by the masons, it is supported around its circumference by a number of wedge-shaped pieces of metal or shims, by means of which the bed is carefully leveled when the nuts on the foundation bolts are screwed tight. The bed-plate is now firmly fastened to the foundation but there is a space between the top of the foundation and bottom of the bed-plate which must be filled.

The two substances most generally used for this purpose are sulphur and Babbitt metal. When either of these substances is used, a clay or putty dam is built around the outside of the bed-plate and the sulphur or metal poured in the joint. Both these substances possess the property of expanding as they solidify, so that the space is not only filled up but the joint is under compression. In heating both these substances, care should be taken that they are not heated too much, only enough heat being necessary to cause them to liquify.

SPARKING AT THE COMMUTATOR

By A. C. Kelly.

One of the most common troubles of electric machines is sparking at the commutator. This may be the result of any one of several causes, which will be considered in turn.

Most alternating current machines have continuous collecting rings which are not likely to give trouble by sparking, but compound-wound alternators have a commutator for rectifying the current for the series-field which requires the same attention as any continuous-current commutator.

Most constant-current machines spark a certain amount even when running under favorable conditions, but as the current is small and the machines are designed to stand sparking, there is no serious objection.

Every dynamo-tender knows that when the load increases on a dynamo, the brushes, as a whole, must be shifted ahead, or in the direction of rotation, and in the case of a motor, the reverse is true; and that metallic brushes require more attention in regard to load variation than carbon brushes. Now, although the average dynamo-tender is aware of the above facts, it seems that but few know the real cause of the same, consequently it will not be amiss to consider this point briefly.

As the current increases or decreases, an E. M. F. of self-induction is set up in the armature coils which opposes the change in the strength of the current. When the current is reversed in the armature coil and is passing from one side of the brush to the other, it is opposed by this E. M. F. of self-induction, so that when one of the commutator bars, to which the coil is connected, is passing from under the brush, the current jumps from the bar through the air to the end of the brush with a resultant spark. This action takes place as each commutator bar passes from under the brush. To prevent this sparking, the brushes are shifted far enough ahead of the actual neutral point to short-circuit the coil when it is in a magnetic field of sufficient strength to generate an E. M. F. in the coil strong enough to neutralize the E. M. F. of self-induction; but if the brushes are shifted too far ahead, the E. M. F. generated in the coil will be much greater than the E. M. F. of self-induction and will not only neutralize the latter, but will

send a local current around through the coil, two bars, and the brush that short-circuited the coil. It is evident that if this current is greater than the current which one-half of the armature is supplying to the external circuit when the coil becomes a part of that half of the armature, the current will be reduced and opposed by the self-induction of the coil and sparking will again result. Now, with metallic brushes, owing to their low resistance, this current is more liable to become excessive than with carbon brushes of higher resistance, consequently the former requires more attention than the latter under the same conditions.

The brushes may be improperly set in either one of two ways: They may, as stated above, be too far one way or the other from the neutral point, or the adjacent sets of brushes may be too far apart or too close together. In the former case, the evil may be remedied by shifting the brushes back and forth with the rocker-arm until the neutral point is found; in the latter case, the distance between the adjacent sets of brushes must be equalized. This can be done by measuring the circumference of the commutator with a piece of twine and setting the brushes a distance apart inversely proportional to the number of poles and length of the twine; that is, if the machine has two poles, set the brushes a distance apart equal to one-half the length of the twine; if the machine has four poles set the brushes apart one-quarter the length of the twine, etc. A better method, however, of finding the proper distance for the adjacent sets of brushes in all commutator machines except those of special design is to divide the total number of commutator bars by the number of poles, as some machines have four poles and only two sets of brushes, which might prove perplexing to the operator. If it is desired to find the distance for the brushes in degrees, divide 360 by the number of poles.

If the armature leads are brought out straight to the commutator bars, the proper position of the brushes will be opposite the space between the pole-pieces. In some types of machines, for the sake of convenience, the armature leads are carried farther ahead of this position, in which case the proper position of the brushes will be ahead of the former position a distance equal to the distance that the armature leads are carried. If the brushes are set very far wrong, a dynamo will not "build up" its voltage and a motor will not start; in the latter case, the fuse will "blow."

Sparking will result from an overload, in which case the armature heats all over, and it is impossible to find a position for the brushes where sparking will cease, though it may be lessened by shifting the brushes ahead in the case of a dynamo, and back in the case of a motor.

On a constant-current circuit, an overload may be due to the current being above normal; or to excessive voltage on a constant-potential circuit; or to a bad external short-circuit, leak, or ground. In the case of a motor on a constant-potential circuit, the trouble may be purely mechanical. For instance, any undue friction, such as the armature shaft not turning freely, or the armature striking the pole-pieces, tends to overload the machine. Under the above conditions, the speed of a motor will be low, and a dynamo will not generate its normal voltage. An external short-circuit will hasten the "building up" of a constant-current dynamo.

Poor brush contact will also cause sparking, and may be due to weak tension of the spring, which should be about three pounds per square inch of brush contact surface. The brush may have poor contact by not fitting the surface of the commutator; or it may be due to a high resistance brush; to a "glass hard" carbon brush; the brush may be stuck in the holder; or, the brush holder may have the wrong angle.

Owing to paraffine being used in the manufacture of carbon brushes, when these brushes get hot they are liable to give off some of the paraffine, which mixes with carbon dust and coats the commutator with a stick substance. Sometimes, owing to the presence of this substance, a dynamo will fail to generate and a motor will fail to start. The remedy is to clean the commutator and use a harder brush. If too much oil is used on a commutator, it will cause sparking, and have a very undesirable effect. If oil must be used on a commutator, it should be used very sparingly and only the best mineral oil should be used; never use vegetable oil. A good way to lubricate a commutator is to get a piece of light canvas, spread a film of vaseline on one side, fold the oil side over on itself and touch the commutator with the canvas, allowing only such vaseline to get on the commutator as comes through the pores of the canvas.

An open-circuited armature produces violent flashing at the commutator. This flashing occurs when the commutator bar nearest the break is passing from under the brush. Sometimes a ball of fire goes all around the commutator. On examination the mica between the bars to which the faulty coil is connected will be found to be seaten away, and the bars badly burned. A temporary remedy is to solder the two bars together, or to insert a "jumper," which is a piece of wire soldered to the two bars, and tape up the ends of the coil, or stager the brushes, that is, set one brush a little ahead of the other so as to bridge over the break. These remedies are not to be recommended, however, for in taking up the ends of the coil and allowing it to run in a magnetic field, a heavy local current may flow in the faulty coil and damage some of the other coils. In all cases, the seat of the trouble should be found and a permanent cure effected.

Sometimes a bad case of "high bars," eccentric commutator, or bad contacts might be mistaken for a broken armature wire, as when under normal speed the flashing is similar. To detect one or more high bars, touch the revolving commutator with the tip of the finger nail and any irregularity can be noted. If the machine generates over 240 volts, a piece of wood or a quill should be used to avoid danger of shock. If there is still any doubt as to the cause of the trouble, turn the machine over slowly in fully excited field; if the coil is broken the machine will flash; if the trouble is due to "high bars," or eccentric commutation, there will be no flash.

Sparking will be caused by bad contacts or loose connections where the armature wires connect to the commutator bars, which burns the bars and has an effect similar to a broken armature wire. These bad contacts should be located and repaired, as filing "bad spots" out of a commutator "occasionally" is a vice rather than a virtue, especially if the machine has a side commutator.

A commutator may be rough or eccentric, owing to poor design, bad material used in its construction, to loose bearings, to bent armature shaft, or to abuse. Smooth the commutator up with a fine file and sandpaper it, using a block of wood cut to fit the surface of the commutator to apply the fine sand-

paper. Never use emery, as it is likely to lodge between the bars and cause local short-circuit, or get under one or more of the brushes and cut the commutator. A commutator in best condition has a glazed chocolate color.

A reversed or short-circuited armature coil will cause a heavy local current to flow and will require an unusual amount of power to run it either as a dynamo or as a motor. A reversed coil can be located by sending a current through each coil in turn and testing the polarity by holding a compass over the coil; when the reversed coil is reached the compass needle will move in the opposite direction. To detect a short-circuited coil, hold a piece of soft iron up to the head of the armature; as the short-circuited coil passes, the iron will be vibrated. Almost any armature will cause a rapid vibration of the iron, but the vibration due to the short-circuited coil will be much stronger. A motor having a short-circuited armature will run with a jerky motion, and in some cases will turn over part way and stop. A voltmeter connected to a generator having a short-circuited armature will fluctuate.

Weak field magnetism may be due to a short-circuited field coil, to a loose connection in the iron circuit, or to one or more of the coils being reversed. A weak field can easily be detected by testing the pole-pieces with a piece of iron, in which case they will show very little magnetic attraction, and owing to the distorting effect of the armature magnetism, the point of minimum sparking will be shifted considerably from normal position. A short-circuited field coil can be detected by feeling the surface of the coils with the hand; if the temperature of one of the coils is much lower than that of the others, it indicates a short-circuit in the cooler coil.

In order to find out if the coils are connected up correctly, take a piece of iron, a wire nail will do very well; hold it loosely between the thumb and fore-finger and place the hand between the poles to be tested; if the coils are correctly connected up the nail will move in an easy plane from one pole to the other; if one coil is reversed, the nail will take up a position at right angles to this plane. If for any reason the field magnetism is unequally distributed, one set of brushes will spark more than the other.

Under ordinary conditions, weakening the field of a motor reduces its counter E. M. F., thus allowing a larger current to flow through the armature, making the armature a powerful magnet, and increasing the speed; but if the field is greatly weakened, or destroyed, the motor will not have the proper torque and will run slow, fail to start, or even run backwards.

If the starting box of a motor has too little resistance, a large current will flow through the armature and start the motor too quickly, and cause bad sparking. This can easily be detected, however, owing to the fact that the brushes will stop sparking when the motor comes up to speed.

Speed variation will cause intermittent sparking and may be due to slipping of the belt, or to "racing" of the driving engine due to some fault of the engine governor.

Vibration will cause steady sparking at the commutator, which may be lessened and sometimes stopped by increasing the tension on the brushes. This is not to be recommended, however, as it increases friction and causes undue wear of the commutator and brushes.

A slight single ground on a metallic return system has very little effect, but a bad ground will overload the machine, and two grounds are identical with short-circuiting. On a grounded return system, a single ground has the same effect as a short-circuit, and if it is a very bad ground, the armature will burn out.

When the bearings become worn on a machine, the armature, of course, is not central between the pole-faces; this has the effect of unbalancing the field and causes sparking. There is hardly any excuse for such a state of affairs, as it requires very little time and experience to find out if the armature is properly centred. By looking through the air gap (the space between the pole-face and the armature core), it can be easily seen if the armature is down, or the distance between the pole-faces and armature core can be measured with a small piece of wood, and the difference, if any, noted.

If it is necessary to renew the bearings, when the job is completed, turn the armature by hand to see if it turns freely. Of course, if the armature is too heavy to turn by hand, other precautions must be taken.

I know of an instance that happened a short while ago where a young man was in charge of a bi-polar constant potential motor in which the bearings had become worn, so that when current was turned on the motor the armature was drawn close to one of the poles and held in that position. An examination soon revealed the fact, and as the motor was a standard type, duplicate parts were carried in stock. New bearings were soon put in, but in his anxiety to get the motor running, the operator turned current on without first turning the armature by hand to see if it ran freely. The motor drew excessive current, and as it was left on a little too long, and as the motor was old and the field coil insulation in bad condition, one of the coils short-circuited and burnt out. He then turned the current off and trying to turn the armature by hand, found that he was unable to move it, whereupon he slacked the bearings up, being sure this time that the armature ran freely unloaded. On turning current on the motor again, to his surprise, the motor ran backwards, which was due to the burning out of the field coil, but as he was at a loss to know the cause of the trouble, the chief electrician was sent for. He, the chief electrician, tested the machine out, located the trouble, and repaired it, but before turning current on the motor he inserted fuses in the line of the proper capacity.

Speed of Induction Motors.

The speed of an induction motor will practically remain constant if the frequency of the system is constant, the full load speed, in good designed motors, being from two to eight per cent. less than the synchronous speeds; but if the frequency is varied, the speed will vary. Change in the voltage does not materially affect the speed but it does affect the output of the motor in the proportion of the square of the increase or decrease of voltage.

In starting an air compressor, it is well to adopt some system, following out a certain order, so that nothing will be overlooked. A good plan is to first start the jacket water, then the lubricators and oil cups, and then the machine, and in shutting down follow the reverse order.

CARE AND MANAGEMENT OF BELTS

By W. A. Dow.

There has been very little printed which gives the engineer very much instruction in regard to belts. The reason for this is probably because modern steam and electrical plants are equipped with direct-connected machines. Most steam or electrical plants more or less use belts and although they are dispensed with when it is possible to do so, their use in small or old plants cannot be excluded without a large cost and it may be safe to say that so long as steam engines and electrical machinery are used in the several branches of manufacturing, belts will have their place along with the rest.

While visiting a number of steam plants, I have learned that the attendant and, in many cases the engineer, knows very little about the care and placing of pulleys for belts and when changes are to be made or a new belt bought, it is often left to the belt manufacturer to decide what is needed. The object of this article is to bring before the readers of this paper a lesson on the care of belts and the placing of pulleys, adjustments and tightness.

In placing a belt around two pulleys, no rule can be given which will account for the stretch in the belt, since the stretch of a belt is variable in different belts of the same length. A belt should be cut shorter than the measured length around the pulleys and it is evident that the length of a belt cannot be obtained exactly by calculation. In practice, to obtain the necessary length of a belt which is to pass around two pulleys already on their places upon the shaft, it is usual to pass a tape measure around the pulleys, the stretch of the line or tape being allowed for the stretch of the belt.

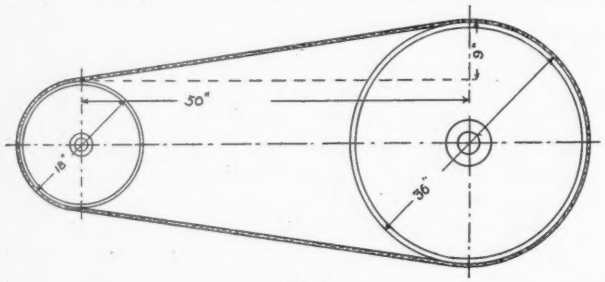


Fig. 1

If the length of a belt for pulleys not in position is required, it may be obtained as follows: Suppose Fig. 1 represents the conditions where the diameter of the large wheel is 36 inches and the diameter of the small wheel 18 inches and the distance between centres is 50 inches; then, $\sqrt{50^2 + 9^2} = \sqrt{2581} = 50.79$ inches, the length of belt on each side tangent to pulleys. This must be multiplied by 2 to get the length of both sides, to which must be added the half circumference of both the larger and smaller pulleys, or, $50.79 \times 2 = 101.58$ inches; half circumference of larger pulley $= 18 \times 3.1416 = 56.54$; half circumference of smaller pulley $= 9 \times 3.1416 = 28.27$; therefore $101.58 + 56.54 + 28.27 = 186.39$ inches is the length of belt required.

The rule, therefore, is: Square the distance between centre of pulleys and square the difference in radii of the two pulleys, add together and extract the square root. Multiply this root by 2 and add the half circumference of each pulley. The result will be the length of the belt. This will give a belt a little too long but allows for a small amount to be cut out of the belt to give the necessary tension. Another rule is as follows: Add the diameters of the two pulleys, divide the result by 2, multiply the quotient by $3\frac{1}{4}$ and add twice the distance between the centre of the shafts. The result will be the length of belt required.

The grain side of the belt should be placed next to the pulley, for with the grain side out, there is a tendency to stretch and crack; this occurs especially when small pulleys are used, whereas if the grain side was next to the pulley, the tendency would be to compress it and prevent either cracking or tearing. Very little of the belt's strength is lost by wearing away its weak side.

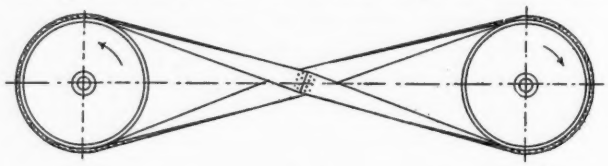


Fig. 3

When two pulleys are placed one above another, the upper pulley will have a grip due to the tension and weight of the belt, whereas if placed horizontally, the weight of the belt will fall equally on both pulleys and for this reason vertical belts of large size require greater tension on the pulleys to transmit the same power as a belt placed horizontally.

As soon as motion is transmitted by a belt from one pulley to another, one side of the belt is under greater tension than the other. The side of the belt to be the most strained is the drive side, which is the side that approaches the driving pulley. The slack side is always that which recedes from the driving pulley. In some cases, the sag of the belt is so great that the arc of contact on the drive pulley is not sufficient to prevent slipping of the belt. When this occurs, which is usually when the slack side is lower side of the belt, an idle pulley is placed between the two main pulleys, as shown in Fig. 2. As will be noticed, this pulley takes up the sag of the belt and allows a longer arc of contact to be made on the drive pulley. When the direction of rotation of the driven pulley is required to be reversed from that of the driving pulley, the belt must be crossed, as shown in Fig. 3. It is evident that cross belts have a greater arc of contact and a greater transmitting power than open belts and the slip is less, but the life of the belt is shortened on account of the two sides of the belt being in constant contact where it crosses.

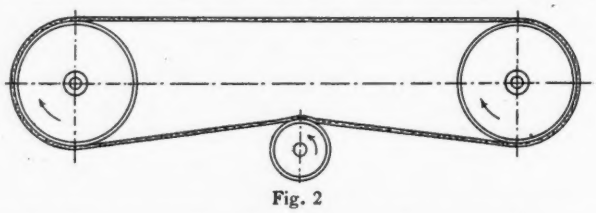


Fig. 2

When a belt connects two pulleys whose planes of rotation are at an angle one to the other, it is necessary to have the centre line of the belt approach the pulley in the plane of the pulley's revolution irrespective of the line of motion of the belt when receding from the pulley, as shown in Fig. 4. This figure represents what is known as a quarter-twist belt. A and B are the two pulleys whose planes of revolutions are at right angles, the belt traveling as denoted by the arrows. The centre line of the belt is in the plane of rotation of A on the side on which it advances to A. Now, if the position of the pulleys is changed, the same rule applies. It is evident, there-

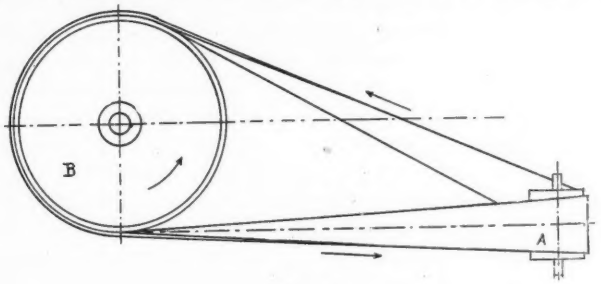


Fig. 4.

fore, that the belt motion must occur in the one direction only and shafts at any angle one to another may have motion communicated from one to the other by a similar belt connection, providing a line at right angles to the axis of one forms also a right angle with the axis of the other.

The axes of shafts may be set at any angle to the plane of rotation, provided that the axle line of pulley A lies at right angles to the imaginary line C, which is at right angles to the axis of the shaft of pulley A, and the side of the driving pulley which delivers the belt is in line with the centre line of the driven pulley.

It sometimes occurs that these provisions cannot be carried out and in those cases pulleys to guide the direction of the motion of the belts must be employed. Thus, in Fig 5, an arrangement of guide or mule pulleys is shown which are placed at the intersection of the middle planes of pulleys A and B. The dotted line TR shows the intersection of the two planes. The axes of the mule pulleys are made to coincide with this line, in which case the belts will have the suitable directions, and can be run in both directions.

An arrangement of guide pulleys by which two pulleys not in the same plane are connected, is shown in Fig. 6. As will be noticed, the arc of contact of the smaller pulley A is increased by the use of the two idlers C and D and the belt may

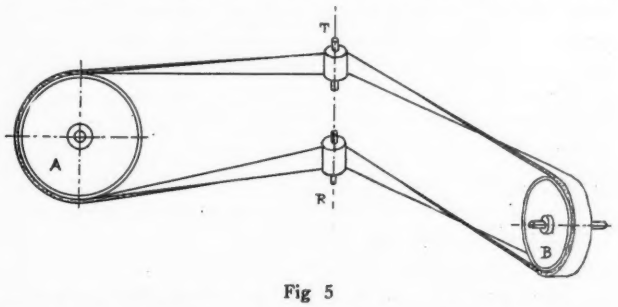


Fig 5

be run in either direction. From the foregoing it can be seen that belts can be run in any direction, providing pulleys are placed in proper positions.

It often happens when new belts are required, the width necessary to transmit a certain horse power must be known. This can be determined by the following formula:

$$W = \frac{800\ H}{S}$$

where W = width of belt in inches, H = horse power to be transmitted and S = speed of belt in feet per minute. If the width is given and it is required to find the number of horse power the belt is capable of transmitting, the formula becomes

$$H = \frac{WS}{800}$$

Suppose, for example, a belt is 8 inches wide and its speed is 2000 feet per minute, then $H = (8 \times 2000) \div 800 = 20$ horse power. This rule is used when both pulleys are of the same diameter. When two pulleys are used of different diameters, multiply the length of the belt in contact on the smaller pulley by 360 and divide the product by the circumference of the pulley. The quotient will be the arc of contact. After the arc of contact is found, subtract it from 180 and multiply the remainder by 3. This last result is to be added

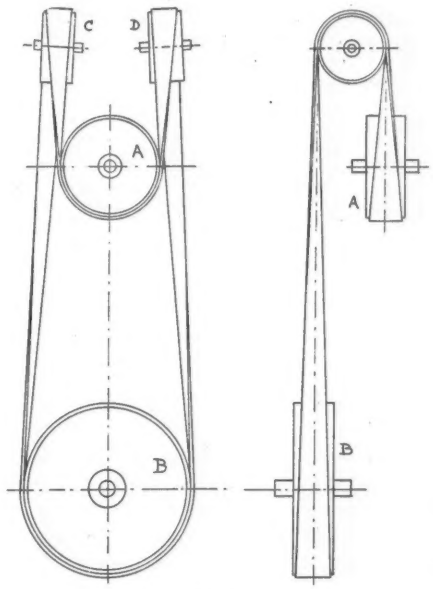


Fig. 6

to 800 and the sum used when computing the power of the belt. The following example shows how the arc of contact is used when computing the power of a belt. Suppose the small pulley to be 24 inches in diameter and the length of contact 30 inches, then $(30 \times 360) \div (24 \div 3.1416) = 143$ degrees. Then $(180 - 143) \times 3 = 111$ and $800 + 111 = 911$, which is the sum to be used in the horse power formula. Suppose under those conditions an 8-inch belt is used which runs 2500 feet per minute, then according to the formula $(2500 \times 8) \div 911 = 21.9$ horse power.

In all the above cases, a single belt was implied in the calculations. When a double belt is used it will transmit 1½ times more power than a single belt and in order to find the width of a double belt multiply the width of a single belt by $^2/_3$. For instance, if it requires a single belt 15 inches in diameter to transmit a certain horse power, it will only require a $^2/_3 \times 15 = 10$-inch double belt to do the same work.

The
Practical Engineer

DEVOTED TO THE ECONOMICAL GENERATION AND UTILIZATION OF POWER

PUBLISHED ON THE FIRST OF EACH MONTH BY

L. L. RICE

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Correspondence solicited, and paid for upon publication. Short articles descriptive of the small problems met with in daily engineering practice are especially desirable. Illustrations prepared from pencil sketch.

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Why Mr. Campbell Failed to Renew Subscription.

Among the numerous letters which we have the pleasure of receiving each morning, the following represents one which is unique in our experience and deserves more than passing notice, because there might be a few other readers who may have thoughts along the same line. The letter reads as follows: "Detroit, Mich., Dear Sirs: I wish to discontinue taking your paper, THE PRACTICAL ENGINEER. The last two numbers have contained far more advertising matter than anything else and as I am not paying for that, I wish to be struck off the list. Norman Campbell."

Correct, Mr. Campbell! You or any other reader are not paying for the advertisement matter. What you are paying for is the reading matter in the columns and thousands of our readers tell us that it is the biggest and the best 50 cents' worth that they ever saw. Every bit of reading matter is carefully selected and concentrated so as not to take up any more room than necessary and also to save as much of the reader's time as possible while giving the necessary facts.

Many of the articles which have appeared in the columns of THE PRACTICAL ENGINEER have been written along the lines which are followed in many engineering colleges in this country and have embraced a scope which it takes years of study to master. We have not yet heard of any college course at 50 cents per year, even if given in concentrated tablets. You have also overlooked the fact, Mr. Campbell, that the last two issues, to which you have referred, have contained more pages of reading matter than any former issues have ever contained.

And the advertisers are not paying for the reading columns! What they are paying for is the privilege of having their advertisement printed in the best manner and upon good quality of paper and of having their engineering products brought before a body of the best engineers in this country, who value education and are willing to pay for it.

While dwelling upon this matter of advertisement, it might be well to mention the fact that only the best manufacturers are represented in the advertising columns of THE PRACTICAL ENGINEER, and no amount of money would be an inducement for accepting an advertisement of a questionable character. The advertiser must be reliable or the advertisement will not be accepted.

Many engineers fail to appreciate the value of reading advertisements. It should be remembered that the best engineering knowledge and experience are constantly being employed in the manufacture of power plant equipment. All that is newest and best is from time to time described in our advertising columns and the engineer who does not read the advertisements regularly cannot possibly keep abreast of his profession and he will often find himself at a disadvantage for want of the proper information.

Well, Mr. Campbell, you are cut off the list and another up-to-date Mr. Campbell has filled your place, but take a tip from us: If you want to get to the top of the ladder, make rungs of your advantages by reading the advertisements as well as the reading columns for the knowledge necessary in your profession.

Proportion of Steam Boilers and Prime Movers in Use.

It is quite natural for anyone who is continually associated with a certain class of apparatus or who lives in a community where that class of apparatus preponderates, to think the same condition prevails throughout other localities. For instance, an engineer who has worked in a large plant where water tube boilers are installed and who sees other plants around him installed with them, is very apt to think that most other plants are equipped with them. While it is true that large plants are being equipped with water tube boilers, eight times as many plants are being equipped with fire tube boilers. The same thing is true with the type of steam engine in use. While, of course, all modern power plants of any size are equipped with automatic cut-off engines, there are, perhaps, four times as many throttling engines in use for various purposes in small sizes as of the variable cut-off type.

These few facts show that the scope of engineering often extends beyond our line of vision and progress is not always being made the fastest along the lines most talked about. To go back to the manufacture of different classes of apparatus for one year, the reports of the Census Bureau show that of all the boilers made in one year, fully 90 per cent. were of the fire tube type, while 10 per cent. of the number were of the water tube type. The capacity of the two types of boilers, however, shows that while the fire tube boilers have a capacity of 67 per cent. of the total, the water tube boilers have a capacity of 33 per cent. of the total. This is because while the average capacity of a fire tube boiler is about 54 horse power, the average of the water tube type is 208 horse power.

The number of throttling engines made in the same year far exceeded the number of cut-off engines, but their comparative size was smaller. Of the total number of engines made, the number of throttling engines was 77 per cent. of the

total, leaving 23 per cent. for the number of variable cut-off engines made. Of the latter, 13 per cent. represented high-speed engines and 10 per cent. low-speed. In horse power capacity, however, the 10 per cent. of the number of engines made represented by the low-speed variable cut-off engine exceeds the 77 per cent. as represented by the throttling engine. The relation in percentage shows that 46 per cent. of the power manufactured in one year went into low-speed variable cut-off engines, 36 per cent. went into throttling engines, while 18 per cent. went into high-speed automatic engines. The reason for this is that the average horse power of a throttling engine is about 30, while the average capacity of a low-speed variable cut-off engine is about 309 horse power, while the high-speed engine with fly-wheel governor shows an average capacity of 82 horse power.

There is one class of engines which has had a wide use during the past ten years and that is the internal combustion engine. These include all motors which use gas, gasolene, kerosene or other vaporized fuels. The total number of engines manufactured of this type closely approximates the number of throttling engines manufactured, but the average horse power of the internal motor is about 9 horse power.

Of the number of water wheels in use, about 70 per cent. belong to the turbine type, which 30 per cent. represent the proportion of impact wheels in use, the average being about 190 horse power, while the average of the impact type is about 62 horse power, which does not, however, represent as good an average as in the other cases owing to the variable heads of water under which they can be used.

Summing up, then, the proportion of prime movers in use in the United States, about 58 per cent. are run by steam, 37 per cent. are run by vaporized fuel and 5 per cent. are run by water power.

———o———

Mechanical Stokers.

The perfect combustion of coal requires the proper amount of air to be supplied to the furnace of the boiler at the right time. This condition is very difficult to fulfil, especially when firing by hand. In ordinary hand firing, the more nearly equal the fireman keeps his fire, the more uniform the thickness of the fire for the draft and duty, the better he distributes each charge of coal and the quicker he closes the fire door, the better the results. If the bed of fuel is too thin, there will be an excess of air, and if too thick, too little air will enter the furnace, both of which will cause a loss in efficiency.

The ideal way to fire a furnace, especially with bituminous coals, is to fire small quantities of coal at frequent intervals and at the same time keep the grates as clean as possible. This, however, requires a degree of skill and an amount of attentiveness which is seldom realized in everyday practice. The practical objection to frequent firing lies in the fact that it is difficult to get good firemen who will fire properly for twelve long hours for the amount of money with which they are rewarded and when a good fireman does come along, he is not likely to remain a fireman very long.

For these reasons, one of the best methods by means of which coal can be supplied to the furnace of a boiler to produce the best results is with mechanical stokers. A mechanical stoker provides for an automatic feed of the coal, which can be varied to suit the conditions of the load and at the same time maintain a clean fire on the grates.

The stoker, however, like any other piece of apparatus, requires intelligent handling and must be given attention so that holes in the fire do not occur or so that clinker does not form to impede the movement of the coal. They are, therefore, an aid to the fireman in producing the proper combustion of the coal.

In many localities, the formation of smoke is objectionable and since perfect combustion means the elimination of smoke, the mechanical stoker is proving a great help in the abatement of the smoke nuisance and at the same time it burns the lower grades of fuel, which would otherwise not be permissible.

The success of a stoker depends to a large extent upon its design and the way in which it is handled, but there are plants where it is not advisable to install them, since the amount saved by them will not compare favorably with the increased cost of the stoking apparatus. The cost of maintenance of automatic stokers is somewhat greater than that of flat grates, and additional labor is required for repairs as well as for tending the coal handling machinery usually installed in connection with them.

There are thousands of plants, however, where the use of the machanical stokers is necessary in order to drive the boilers up to their capacity and at the same time produce smokeless and economical combustion.

———o———

The Early Use of High Steam Pressure.

The earliest use of high steam pressures in this country dates back to the early fifties, at which time many steamboats on the Mississippi River were carrying pressures of 100 pounds and over. This was in marked contrast to the low pressures carried in stationary practice at that time, and even on trans-Atlantic steamships, 30 to 35 pounds pressure was high. The Great Eastern, which made her first voyage across the Atlantic in 1860, carried only about 24 pounds steam pressure, although it was the largest steamship ever built and held that record until 1899.

In connection with the early use of high pressures on the Mississippi, many interesting stories have been told especially relating to the frequency with which the boilers used to explode and send many persons into eternity. The early owners of steamboats in that class of service were offered such large bonuses to make quick time that the many explosions did not deter other steamboats from hanging extra weights on the safety valve.

One of these stories which was recently told at an engineers' meeting, related to the trouble a passenger had in going from Louisville to New Orleans. It seems that the first boat the passenger took was destroyed by an explosion and, having survived that, he managed to catch another one going in the same direction. He was only on that boat a short time when it also exploded. This time he was blown up into the air and landed on the roof of a small hut along the banks. He broke through the roof and landed in the centre of the dining table where the occupants were eating. Not very much hurt, he got up, brushed off his clothes and surveyed the damage. "What do I owe you for the damage done?" he said. The owner said about five dollars would cover it. "Too much" he said. "Why only last week I was blown through a two-story house and they only charged me one dollar and a half."

LETTERS FROM ENGINEERS

IN ORDER to make this department of THE PRACTICAL ENGINEER as interesting as possible, a moderate rate will be paid by us for all contributions published under this heading. However, we do not assume responsibility for the ideas or opinions expressed. None need hesitate to contribute because of inability to draw or write well. We will redraw or revise whenever necessary—it is the idea we want. New ways of doing old things, criticisms of accepted theories, and general engine-room experiences are especially solicited.

Low Pressure Cylinder Cards Taken From Cross-Compound Pumping Engine.

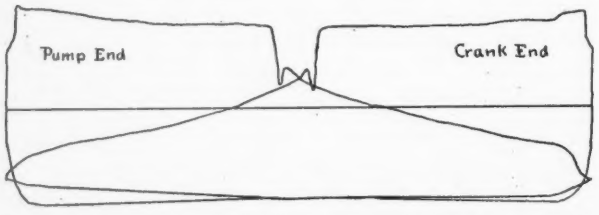
EDITOR THE PRACTICAL ENGINEER:

Engineers frequently, in their professional capacity, run up against some very peculiar ideas in reference to piping, saving fuel and other important matters connected with pumping and power plants.

The accompanying indicator cards, No. 1 and No. 2, were taken from the low pressure cylinder of a cross-compound pumping engine having cylinders 27″ and 54″ with a common stroke of 60 inches, the engine running from 16 to 20 revolutions per minute, the cards being taken when the engine was running 16 revolutions.

This pump is one of three used in the Standard Oil Co.'s plant at Point Breeze, Philadelphia. They are side-crank, flywheel pattern, having Corliss valve gear on both high and low pressure cylinders. The high pressure cylinder exhausts into a receiver carried on top of cylinders. This receiver is furnished with reheating coil. The valve gear on both cylinders is as near perfection as is to be found. The water pump cylinders are placed tandem and both draw their supply direct from river 200 feet away.

There is a standard type of jet condenser having a vertical wet vacuum pump. The exhaust of the steam cylinder of this pump is arranged for exhausting both into the receiver of main engine or out into the atmosphere. The steam for heating coils or pipes is taken from a point in main steam pipe and the pressure is nearly the same as that in high pressure cylinder.

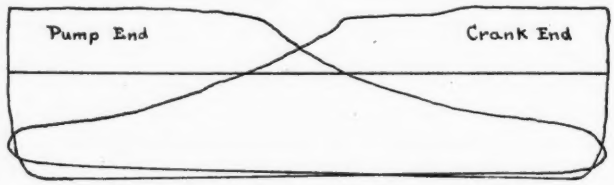


Card No 1.—Exhaust from Auxiliaries connected to Receiver of Engine

It has been the practice of some engineers to advocate the piping of the exhaust from auxiliaries direct to receivers of compound and triple engines while others advocate the running of all auxiliaries condensing.

The experience of the writer has been that it is bad practice to exhaust into the receivers, because when this steam is put into the receiver the horse power of the low pressure cylinder of the engine is much greater than that for which it was designed, which puts strains on the shaft and bearings which have no right to exist.

Card No. 1 was taken from the low pressure cylinder when the auxiliaries were exhausting into the receiver, and Card No. 2 was taken when the exhaust was cut out of receiver. In the latter case, the horse power developed by the low pressure cylinder was almost exactly the same as that developed in the high pressure cylinder, but with conditions as represented by Card No. 1 the power developed in the low pressure cylinder was very much greater. It was also noticed that when the auxiliary exhaust was used in receiver, the brasses showed the effect of unequal work done in the two cylinders.



Card No. 2.—Exhaust from Auxiliaries cut out of Receiver

The peculiar construction of Card No. 1 will be observed, and the difference when Card No. 2 was taken. The writer would like to hear comments of these cards from engineers.

Phila., Pa. C. S. L.

Did You Ever Make a Blunder? This Engineer Did.

EDITOR THE PRACTICAL ENGINEER:

Where is the engineer who has not at some time in his career made a blunder which has caused him a large amount of trouble and anxiety and which has caused a bill for expenses for his employer? Sometimes, however, these blunders are not of much importance and are discovered by the engineer before any damage is done.

One time, in my early days at the business, while running a pair of condensing engines of 1600 horse power capacity which were connected with several water wheels of about the same power, I made a blunder which caused considerable agitation on my part and some sarcastic remarks by the superintendent. It was my usual custom when starting up to signal first for water on the wheels and then put on a little steam, just enough to run the machinery slowly. After a few minutes, I would again signal to the wheelman to put all the water on the wheels and then, as it was needed I would open the throttle and admit steam to the engine.

On this day I started as usual and when the water gates were opened full the engine came up to speed and everything seemed to be all right. After a few minutes, the engine began to slow down and after looking at the gauges I found the vacuum was down to 10 inches. I made a frantic dash for the pump and a quick examination of the valves and found everything all right. Of course, every engineer will know about how I felt at that time. The perspiration was rolling down my face, I was hurrying about, trying to find out what the trouble was and all the time the engine was going slower and slower. The overseer and superintendent came in about that time and wanted to know what was the trouble. I was hardly prepared to give them any definite answer, for all the information I could obtain by examining everything connected with the engine seemed to prove that nothing was wrong.

The superintendent said I had better shut down and find the trouble. I went to the throttle valves, when "lo and behold" I found them open only one turn of the wheel. I quickly turned on a full head of steam and the engine came up to speed, the vacuum gauge moved up to 27 inches and everything was O. K. except my feelings. The remarks of the supt. were somewhat sarcastic and did not tend to make me feel any better, but the lesson was learned and that blunder was never repeated. S. J. S.

Comments on Compression.

EDITOR THE PRACTICAL ENGINEER:

In the November issue of THE PRACTICAL ENGINEER, Mr. Chas. J. Mason has a very interesting letter on "Compression" and in some parts of the letter I agree with him, especially in changing the exhaust valve on the low-pressure cylinder when changing the engine from condensing to non-condensin, as I have had personal experience in this matter. Still these cards do not agree entirely with my experience, as Card "A" which is non-condensing, shows a too late admission or initial pressure. My reason for saying this is that Card "B" non-condensing shows the same height of compression but an earlier initial pressure. This latter card also shows that the load on the low-pressure side has increased considerably. The exhaust on the crank end is also later and shows more back pressure. In adjusting the lap for the exhaust valves, the release should be made earlier, instead of later, if the eccentric has not been moved.

Now, Card "A" condensing shows that the low-pressure cylinder head end is doing more than $^2/_3$ of the work before Mr. Mason altered the cut-off and his crank end exhaust valve shows a very nice compression without any alteration. His head end card as shown in Card "B" condensing he has, of course, improved. Taking the lap from the exhaust valves to get less compression is Mr. Mason's theory, as I understand it, and his way of doing this may be all right but the cards do not show the early release they should and I am sure that the area of the non-condensing cards is not alike, as Card "B" non-condensing is doing considerably more work than Card "A" non-condensing, all alterations in the valves being made without moving the eccentric, as I take it.

Fall River, Mass. M. H. H.

Quick Repair to Governor.

EDITOR THE PRACTICAL ENGINEER:

I have an automatic cut-off engine with a shaft governor, the regular speed of the engine being 125 revolutions per minute. A few days ago, a coiled spring broke, slowing the engine down, and in about one minute employees from all parts of the factory came into the engine room and began kidding me about the slow power and belt slipping, as if I didn't know what the trouble was.

The spring which broke was about 14 inches long and very stiff. I had no extra spring, only a brass spring 6 inches long which was used on another machine. I shut down the engine, took the short brass spring, hooked together some S-hooks to make it longer, loosened up thumb screws that stretched springs and put the brass spring in. As it was weaker than the original spring, I took off one of the weights on the weight arms and started up.

With the help of the superintendent, I had her running in four minutes and making her 125 revolutions per minute, which I think is a quick repair. I have received new spring from engine builders but haven't put it in yet, as the brass one is doing all right.

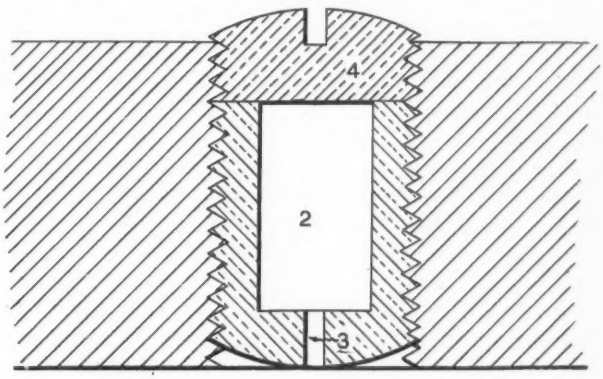
Danbury, Conn. J. M.

Home-Made Loose Pulley Oiler.

EDITOR THE PRACTICAL ENGINEER:

Recently I saw a simple oiling device in a plant which I visited, which they called a home-made loose pulley oiler; rather a long name, but under certain conditions, it fills the bill.

It seems they wanted to put an oil cup on a hub that was tapped to receive a large set screw, but they had no tap for cutting a thread to fit the one on a standard size oil cup; and to have a cup made with a screw thread on it to fit the hole already made was out of the question, so the engineer, who is a bright sort of fellow, designed the arrangement shown. He found a piece of brass which had a square hole, 2, cast in it.



Home-made Loose Pulley Oiler

At a neighboring machine shop they cut a standard screw thread on it, and drilled a small oil hole, 3, in the end of it. This piece, when screwed home in the hub by a square bar and a monkey-wrench, made the bottom of the oil cup. The top or cap, 4, was made by cutting a screw-driver slot in the end of a bolt, and then cutting off a suitable length of the screw.

A. E. RHODES.

More Massachusetts Examination Questions.

EDITOR THE PRACTICAL ENGINEER:

I wish to thank Mr. Chas. J. Mason for his kindness in answering my questions in the November issue of THE PRACTICAL ENGINEER. I fully agree with that gentleman that it is not a fair deal to ask such questions of an engineer, even though he has charge of thousands of horse power and desires a first-class license. There are many subjects concerning the safe and economical operation of plants which take up the mind of the man in charge and not until these are mastered do I believe in figuring and studying such problems, but when State examiners ask such questions and you appeal from their decision to the entire board, whose decision is final, what more can an engineer do?

The following are questions asked me when I secured my third and second licenses, which are more practical:

In a battery of boilers with all safety valves set for 125 pounds, how many will open and relieve the boilers? Explain in detail.

Is it best to have one safety valve of proper area or two valves with a combined area equal to one large one? Give reasons.

For what would you look when examining a horizontal return tubular boiler internally and externally?

How are water tube boilers set?

What is the best method of connecting up and protecting a blow-off pipe?

If you had an automatic and a slide valve engine of the same power and speed, taking steam at the same pressure, and a gauge is connected to the cylinder of each, which engine will register the highest pressure and why?

What would happen if the governor belt broke or ran off a slide valve or a four-valve engine?

Can you tell by looking at these two types if that condition would happen and how it could be prevented?

Name the causes that will prevent the steam valves of Corliss engine from picking up.

If you had an engine with solid end connecting rod and you desired to shim the wrist pin boxes, explain method you would use in detail.

These questions should be interesting as showing a few of the questions asked by examiners in Massachusetts.

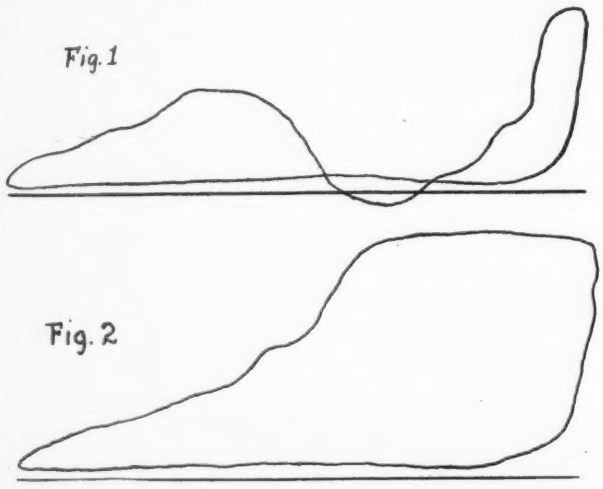
Lawrence, Mass. A. W. B. E.

Indicator Experiences.

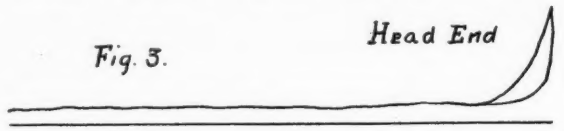
EDITOR THE PRACTICAL ENGINEER:

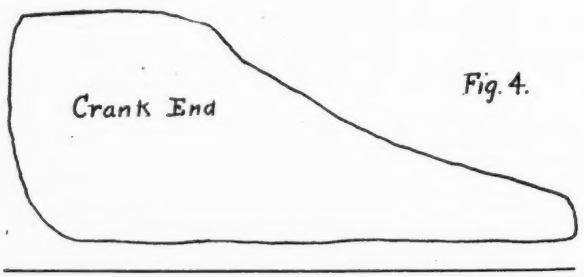
The following are a few of the indicator experiences which I have had and should prove instructive:

Fig. 1 is a card that offers very convincing evidence of the value of the indicator in correcting faults in valve setting. It will be noticed that the steam line drops below the atmospheric line and then rises to very near the initial pressure. This state



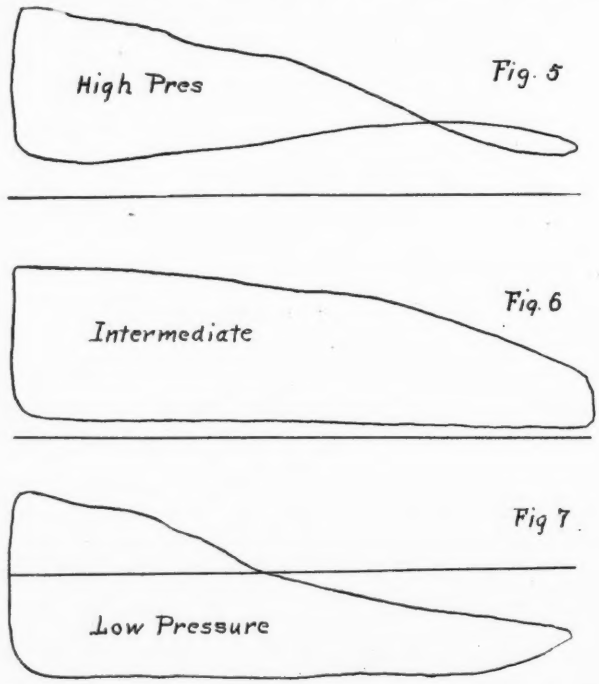
of affairs might have gone on until the firm became bankrupt from buying coal, if the defect had not been revealed by the indicator. The head fireman reported an increase in fuel consumption, which he imagined was due to an increase in the load on engines. At the first opportunity an indicator was applied and the card revealed the fault and it was then easy to prescribe a remedy. The valves of this engine were of the gridiron type with riding cut-off. This valve worked on the surface of the steam side of the admission valve. The rod of this cut-off valve, which was moved by the eccentric of the





shaft governor, had become loose in its crosshead and moved out of position in such a manner as to cause the defective steam distribution. After the correction was made in valve setting the card shown, Fig. 2, was taken.

Fig. 3 is a card taken from the head-end of the high-pressure cylinder of a 1500 horse power cross-compound engine equipped with automatic shaft governor. Fig. 4 is a card taken from the crank end of same cylinder. It will be noticed that the crank end is doing all the work. In this case it was found that the rod of the steam admission valve had worked out of its crosshead and was running with the cut-off in such a manner that very little, if any, steam port opening was obtained, consequently the governor threw all the load on the crank end of cylinder. It is hardly necessary to add that this was a very



bad state of affairs, but outside of an unusual click in the valves, it was not noticeable in the running of the engine. But when the indicator was applied, the above-mentioned defects were discovered.

A pumping station in which the writer was employed as chief engineer was equipped with two vertical, triple-expansion engines of the Corliss pattern. These engines were run condensing, and had a combined capacity of 13,000,000 gallons per day. The speed and pressure were regulated by throttling the steam to the high-pressure cylinder and allowing the admission valves of the intermediate and low-pressure cylinder to remain open during the entire stroke of piston. Three boilers were in service, and sometimes forced very hard to keep pressure up to 60 pounds on the mains. It is obvious that the duty of the pumps was very low. The engines ran unsteady and it seemed impossible to keep the high-pressure side from

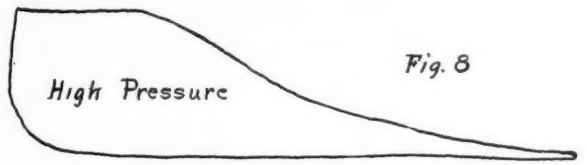


Fig. 8

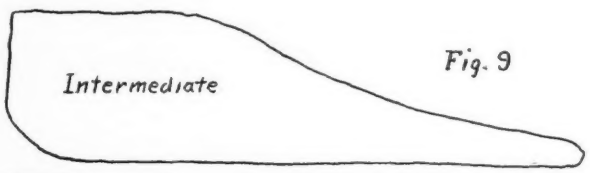


Fig. 9

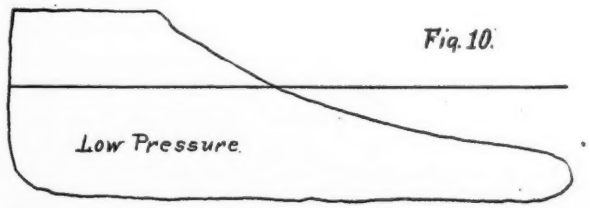


Fig. 10

pounding. Every effort to take up lateral motion of guides as to make engines run quiet by keying, only resulted in trouble with hot bearings. After a few repairs to receiver, reheating tubes and the placing of new gaskets in steam jackets of cylinders, the engines were started with cut-off and pressure regulator in operation. An indicator was applied and card 5 was taken from high-pressure cylinder, card 6 from the intermediate and card 7 from the low-pressure cylinder.

The indicator plainly shows the fault in steam distribution, which was only guessed at before. The high-pressure had been running underloaded, while the intermediate cylinder had been overloaded and the release on the low-pressure very late. The exhaust valves on both head and crank ends were made to open easier by shortening the length of the reach-rod between wrist-plate and rocker-shaft. The cut-off was made equal on all cylinders by changing the position of tripping cams. Cards 8, 9 and 10 were then taken. We were enabled to cut out one boiler, thereby making a saving of nearly eleven hundred dollars per year in fuel consumption, besides increasing our pumpage nearly one-half million gallons per day.

Columbus, Ohio. JOHN BURNS.

Calculations for Increasing Horse Power of Engine by Increasing the Speed and Still Maintain Same Speed of Jackshaft.

EDITOR THE PRACTICAL ENGINEER:

Recently the following question was asked by an engineer: "I have an engine, 22-inch cylinder, 48-inch stroke, turning 70 revolutions per minute, boiler pressure 95 pounds per square inch and it developed 264 horse power. The fly-wheel of this engine is 16 feet in diameter and drives a jackshaft pulley of 4 feet diameter. Now, it is required to increase the horse power to 330 and I wish to do it by increasing the speed rather than by increasing the pressure because of certain limitations. To what speed must the engine be increased to develop 330 horse power, the other conditions remaining the same, and what size pulley will I require on the jackshaft to maintain the present speed?"

Perhaps it would interest the readers of this paper to learn just how such problems are taken care of, hence the following explanation. First of all, let us find with what mean effective pressure the 264 horse power was obtained. In the question it does not state what the mean effective pressure was nor at what part of the stroke the steam was cut-off, but by transposing the terms of the general horse power formula, we can at once obtain the factor we desire.

In the formula, $PLAN \div 33{,}000 = H.\ P.$, everything is known but P, so that the formula becomes

$$264 = \frac{P \times 4 \times 380.13 \times 140}{33{,}000}$$

and by transposing the terms, the missing factor P can be obtained, or,

$$P = \frac{33{,}000 \times 264}{4 \times 380.13 \times 140} = 40.92 \text{ lbs.}$$

which is the mean effective pressure.

As it is desired to increase the horse power from 264 to 330 with the same mean effective pressure, it follows that the only other factor which can be changed is N, the number of strokes per minute. This value can be found in the same manner as P was found above, or

$$330 = \frac{40.92 \times 4 \times 380.13 \times N}{33{,}000}, \text{ or}$$

$$N = \frac{33{,}000 \times 330}{40.92 \times 4 \times 380.13} = 175$$

and since there are two strokes per revolution, the number of revolutions becomes $175 \div 2 = 87.5$.

Although in the problem it is desired to increase the horse power of the engine, it is also desired to maintain the same speed of the jackshaft which, of course, necessitates changing the pulley thereon because of the speed of the engine flywheel (which is also the driving wheel) having been increased.

First we will see at what speed the jackshaft is now running. The flywheel is 16 feet in diameter and turns 70 times a minute. The pulley on the jackshaft is 4 feet in diameter and

14 feet, the length of yz; $3.45 + 4 = 7.45$, the distance z has therefore turns $16 \div 4$, or four times as fast, or $4 \times 70 = 280$ revolutions per minute. This 280 revolutions is not to be changed.

The required diameter can then be found as follows: (New No. of Revs. at Engine $\times$ Diam. of Flywheel) $\div$ Revs. of Jackshaft = Diam. of Pulley required on jackshaft, or,

$$\frac{87.5 \times 16}{280} = 5 \text{ ft., diam. of new}$$

pulley for jackshaft.

The whole answer to the question is, then: "With the same mean effective pressure, the speed of the engine must be increased from 70 revolutions to 85 revolutions per minute in order to increase the horse power from 264 to 330. And in order not to disturb the speed of the jackshaft, the 4 foot pulley must be replaced by one of 5 feet in diameter."

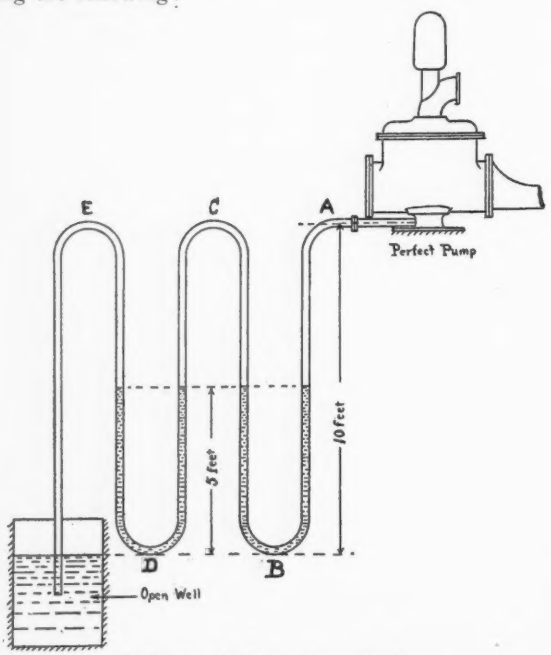
By working backwards, so to speak, the reader can prove the correctness of the foregoing figures. Of course, slippage of belts and other inequalities have not been considered in the calculations.

CHAS. J. MASON.

Hydrostatically Impossible; Hydraulically It Can be Accomplished.

EDITOR THE PRACTICAL ENGINEER:

As none of your correspondents seem to have noticed the *joker* in your *trick* pump problem, I take the liberty of submitting the following:



A. L. H's Solution to Pump Problem

From a hydrostatic point of view, the problem would be impossible; from a hydraulic point of view it can be accomplished by a good pump. If we ignore the ability of currents of air or water at high velocities to carry each other along, the conditions will be as follows:

The pump will start and exhaust the air from the tube AB. The tension of the air at C will force the water to AB and the air at E will force the water at D part way up DC and the atmosphere at F will force water from the tank a short distance up tube FE.

As the pump continues to run, the air at C passing to B will bubble up through water in AB and escape through the pump. The water at D will then rise to C and the water will continue to rise in FE. As the pump still continues, the air at E will rise through water in CD and AB as before. When the water had risen to FE, there would be three columns of water each 10 feet high or 30 feet to be supported by the pump, which no practical pump could do. Therefore, it will not operate.

But take the other view. Let the pump be started at a good speed; the water will rise as before to A in AB; the air at C passing B will rise, carrying slugs of water with it through AB. The water at D, passing C, will carry air with it down tube CB and the air will carry the water up AB as before. The same will be repeated in all the loops until the system is full of water and working O. K. Therefore the problem is feasible.

Phila, Pa. A. L. H.

Pump will Draw Water.

EDITOR THE PRACTICAL ENGINEER:

I have seen your pump problem in a recent issue, where the suction pipe of the pump has two loops in it, each half full of water. I am interested in pump problems and wish to give my opinion that the pump would take water and at the same duty on the pump as if the pipe was straightened out, less a slight additional friction at turning the loops.

Terre Haute, Ind. L. D. C.

Expansion of Air in Tubes Makes Pump Problem Complex.

EDITOR THE PRACTICAL ENGINEER:

As none of the answers to the pump problem in the November issue seemed to me to state very clearly what takes place in the suction pipe of the pump, I would like to submit the following:

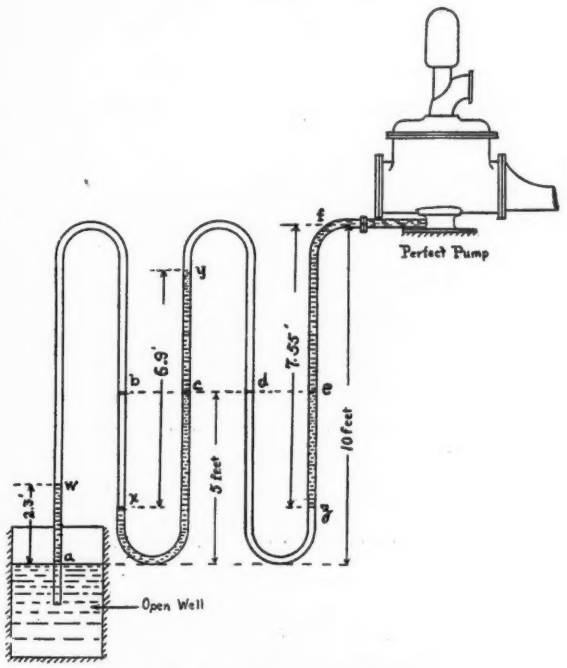
The fact that the air above the different columns of water will expand as soon as any pressure is removed at the pump end makes the problem a little complex but by calculating the lift for a number of different positions of the water and air, after it begins to flow, it can be seen that at no time will the lift be excessive.

For illustration, I will make the calculation when the column of water has reached the height of 2.3 above the well in which case the pressure will equal one pound. With an atmospheric pressure of 14 pounds, say, the air colmn wx will have a pressure of 13 pounds, as the pressure of aw and wx must balance the atmosphere. Now neglecting the extra length of the return bends, wx was originally 15 feet and yz was 10 feet and in a pipe of uniform diameter the volume is proportional to the length. Therefore the length wx is $(15 \times 14) \div 13 = 16.15$ feet which is 1.15 feet longer than before, making x fall $2.3 + 1.15 = 3.45$ feet below b. This will force y 3.45 feet above c and 6.9 feet above x. The backward pressure of xy will then be due to the weight per square inch of the column xy or $6.9 = 2.3 = 3$ pounds.

Repeating the same operation to find the length of yz, we have: $13 - 3 = 10$ pounds pressure of yz; $(10 \times 14) \div 10 =$

advanced from *d*; 15 feet — 7.45 feet = 7.55 feet, the length of *zf*. Therefore the total lift at this time is 2.3 + 6.9 + 7.55 = 16.75 feet.

This is only approximately correct as the effects of friction and inertia have been left out of consideration to simplify the



H. H. H's Solution of Pump Problem

problem. But, of course, in order that there be any motion, the expansion of the different air columns will have to be a little in excess of what has been calculated or, in other words, the different vacua will each have to be a little greater.

St. Louis, Mo. H. H. H.

Cause and Remedy of Trouble with Cross Shaft Bearing.

EDITOR THE PRACTICAL ENGINEER:

A short time ago I had occasion to call on an engineer friend of mine and while in his engine room saw something which I think worth putting in the columns of "The Practical Engineer." As I entered the engine room of the pump house (for the plant was a water works), a man, apparently a machinist, entered another door. I stepped up to the engineer, greeted him and the machinist did the same and he presented the engineer with a slip of paper which stated that he was a machinist from the shop where the pump was built, and that being an expert, etc., he would remedy any defects the pump might show. The machinist stepped near to the pump, which was a duplex triple tandem compound horizontal condensing engine of about 6 million gallons per 24 hours capacity.

As the machinist looked at the pump he wanted to know what was the matter with it, and the engineer pointed out to him that the right side short stroked very much on one end when the service was light, but when the pump ran at its full capacity, it traveled to full stroke on both sides all right. Just then the pump began to increase its speed and, sure enough, it did work all right. The machinist wanted to know if that was all that was wrong, and the engineer told him it was. The machinist then told the engineer that all piston direct pressure pumps would short stroke at times, on one side or the other, and that it could be easily overcome by admitting live steam through the by-pass valve from the main steam pipe to the intermediate cylinders. "You have no more use for me here, so I will return to the shop."

After the machinist left the place, the pump slacked down and the stroke of the right side kept getting shorter, until I suggested to the engineer to start the other pump and look this one over and see what was wrong with it. So after an hour or so we began by taking off the steam chest covers and thoroughly examining each valve, valve clamps, and balance arrangement, and I made sure that none of them was blowing through. By placing them at the centre of their motion and then pouring water in the chest, if it would remain in the chest a reasonable length of time I was assured that there were no serious leaks; in fact, before I could put the covers on I had to raise each valve to drain the water off, as each valve proved to be steam tight. After I examined the sixth or last valve and found it all right, I turned my attention to the steam jackets on the intermediate and low pressure cylinders.

Opening the chests of each of the intermediate and low-pressure cylinders I turned on the jacket steam valve, and with the trap in drain line closed, I watched for a leak in any one of the steam chests. I moved the pistons of each side of the pump to give a steam port opening on either end of the cylinders, but to my surprise there was no signs of a leak. I began to think that I had found something that I could not master. I even tried the cross exhaust valves but they were all right, when it occurred to me to disconnect the rocker arms which operate the valve stems on each side and see if they were free to move in their bearings in the rocker brackets. The left side I found entirely free to move for the entire stroke but when I disconnected the right one, I could not move it with a sledge. In close examination I found the shaft had fired in the box of the cross shaft bracket on the right side. The entire cross shaft arrangement with both brackets had to be taken to the shop, and the shaft had to be pressed out of the box by several tons pressure. After the shaft was taken from the bracket, it was put in the lathe to determine whether it could be used again or not, and it was found to be strained tortionally ⅜ of an inch in the circumference of the shaft, which was 3″ diameter. This defect, and the fact that the box had to be bored out, made it advisable to use an entirely new cross shaft.

After the job was finished, I examined the oil holes to this particular bearing and to my surprise found that there was no way to oil the shaft at all. When the rocker boxes are properly made, there is a large space cored out over the bearing and a small pocket is left over the bearing so that by drilling a hole in the side of this pocket and tapping it out, a pipe can be fitted to it to which an oil cup can be attached. Now the pipe was put in all right and the oil fed through the cup to the cored space, but oil did not reach the shaft, for the oil hole was filled up with core sand and a small piece of casting. I called the shop foreman's attention to this condition of affairs, and suggested to him to put an oil hole through the side of the bracket, and he did and after having the cored space thoroughly cleaned out, the new shaft was put in and is running to-day. There was a lawsuit with regard to the bill for repairs but the water company won out.

QUESTIONS and ANSWERS

THE editor will be glad to receive from the readers of THE PRACTICAL ENGINEER, such questions relating to engineering subjects, as may, from time to time, occur to them. All questions and answers should be addressed to the editor and accompanied by the name and address of the writer, which will not be published, however, unless especially desired. It is the intention that questions shall be answered by the readers, and even though the editor may, from time to time, publish answers and questions, he especially desires the readers in such cases to contribute any further information, in connection with the points raised, that they may consider of interest. All questions and answers received by the editor will be published, as far as practicable, but he reserves the right of editing or rejecting any communication.

Valve Gear and Condensing Problems.

EDITOR THE PRACTICAL ENGINEER:

Kindly answer me the following questions:

1. What alterations would have to be made on a slide valve engine to hasten the cut-off without changing the lead?

2. During an engine test 960 pounds of exhaust steam passed through a surface condenser and 13,580 pounds of water were required for condensation. Average pressure of the exhaust steam was 7 pounds above vacuum. The condensing water entered at an average temperature of 52 degrees Fahr. and left the condenser at an average of 120 degrees. What was the average temperature of the condensed steam on leaving the condenser?

Minneapolis, Minn. M. O. N.

1. With a given slide-valve engine, the dimensions of the eccentric and valve are fixed so that when setting the valve, the only thing that can be changed is the angular advance. Increasing the angular advance shortens cut-off but makes the lead greater and decreasing the angular advance makes cut-off later and decreases the amount of lead. If, therefore, the lead is to remain the same when cut-off takes place earlier, more steam lap must be added to the valve when the angle of advance is made greater. This, however, will only be true for one setting of the valve. In practice, to overcome this, some sort of link motion must be used which involves the use of two eccentrics, the valve usually partaking of a combination of the motion of each eccentric. This is illustrated in locomotive and marine engine valve gears. With these forms of valve gear, the dimensions of the link must be such that when the go-ahead eccentric is given a certain angle of advance and the backing eccentric is given a less angular advance, the lead will always be constant for any cut-off.

2. The formula for finding the temperature of the condensed steam is as follows:

Let W = weight of condensing water.
w = weight of condensed steam.
T = temperature of steam.
t = original temperature of condensing water.
t'' = final temperature of condensing water.
t' = temperature of condensed steam.
H = latent heat of evaporation.

Then

$$W(t'' - t) = w(T - t') + w\,H$$

which shows the relation between the amount of heat given to condensing water and the amount given up by the condensed steam. From the above problem, $W = 13{,}580$, $w = 960$, T, corresponding to 7 pounds above vacuum, $= 177$, $t = 52$, $t'' = 120$ and $H = 990$.

Then

$$13{,}580(120 - 52) = 960(177 - t') + 960 \times 990$$
$$13{,}580 \times 72 = 169{,}920 - 960\,t' + 950{,}400$$
$$977{,}760 = 1{,}120{,}320 - 960\,t'$$
$$960\,t' = 142{,}560$$
$$t = 148.5 \text{ degrees,}$$

which is the temperature of the condensed steam on leaving the condenser.—[Ed.]

Returns for Heating System.

EDITOR THE PRACTICAL ENGINEER:

I have charge of an engine and boiler of about 50 horse power, running under 60 pounds of steam, in a woolen mill. The building is heated by steam taken from the top of boiler dome. We have trouble returning the water of condensation to boiler. We have tried putting in a check valve but we still have trouble. How should the returns be connected to the boiler?

Beeton, Canada. H. H.

Whether the water of condensation from a high-pressure heating system can be returned to the boiler depends upon the

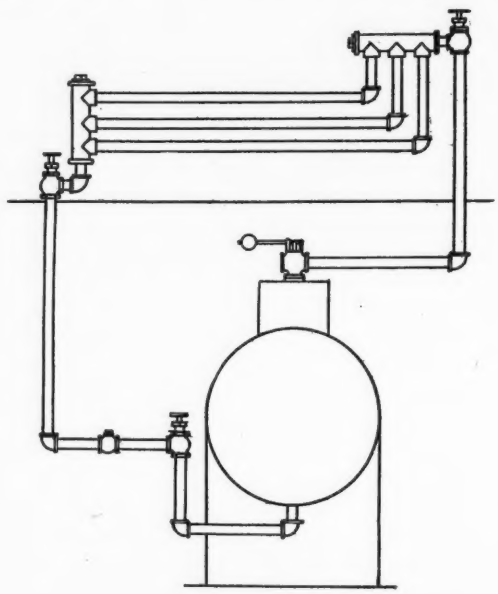


Fig. 2

conditions and the system of piping, but there are various ways which have been used successfully. Several of these methods are shown in an article in the November *Graphite*, by W. H. Wakeman, and will answer the above question. Fig. 1 illustrates an arrangement for returning the water of condensation without a pump. Steam at high pressure is delivered directly to heating coils located above the boiler and the returning condensed steam enters through a pipe that is entirely independent of all other connections. This is a safe plan because there is nothing to hinder its continuous operation, assuming that the main steam pipe is large enough to maintain full boiler pressure. A swing check valve should be located

in the return pipe near the boiler to prevent water being forced backward through this pipe.

Fig. 2 illustrates a different arrangement of piping, although it comes under the same general head as the previous illustration. Steam is taken from the dome and delivered to heating

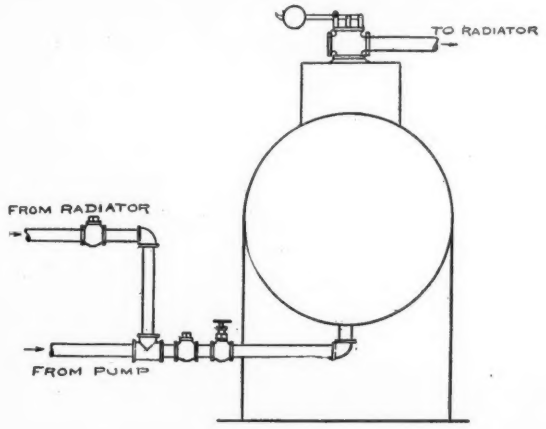


Fig. 2

pipes the same as before, and the return pipe is arranged in the same way, but steam is taken from the boiler through another pipe to run an engine, consequently a pump or an injector must be used to put in water enough to supply the necessary steam which does not come back in the form of hot water.

The upper return pipe is "From radiator" while the lower one is "From pump." They are joined together by means of a tee, as shown, and if the pipe between this point and the interior of boiler is of ample size, the arrangement will work well, but if not, the pump will create excessive pressure in the return pipe "From radiator," thus keeping this check valve

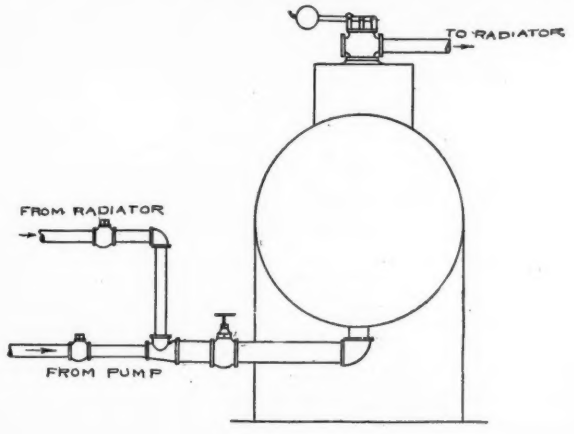


Fig. 3

closed and preventing hot water from the heating system from flowing freely into the boiler.

It will be noted that water from the pump is forced through one check valve, while that coming from the heating system must go through two of them, although there is no pump on this line to make the action positive.

A better arrangement is shown in Fig. 3, as the check valve in the pump line is on the outer side of the tee, thus making less friction for the returning water to overcome. The outlet of this tee is one size larger than the inlet, therefore friction from this point is reduced, consequently the upper check valve is left free to act.

Economical Engines. Size of Valve Ports.

EDITOR THE PRACTICAL ENGINEER:

1. Which is the most economical when running full load, the slide valve engine or the automatic engine?

2. Which has the largest ports, the slide valve engine or the automatic engine, for the same horse power?

Baltimore, Md. F. I. I.

1. If by a slide valve engine, a throttling engine is meant, then the automatic cut-off engine is more economical at full load. But slide valve engines are often automatic engines and whether they are more economical than other kinds of automatic cut-off engines depends upon the design of the valve gear for that particular load under consideration. If a slide valve automatic engine is designed to give its maximum efficiency at a certain load, then at any other load the functions of admission, cut-off, release and compression are so involved that its economy is very much reduced. A four-valve automatic engine has its strong points in the fact that it will give a varying admission without introducing irregularities in the exhaust functions.

2. The size of the steam ports of an engine is decided by the size of the cylinder and speed of the piston. In general, however, the slide valve engine must have larger ports than a four-valve engine because the steam must travel a longer distance from the steam chest to the cylinder than in the four-valve type. This has a tendency to produce wire-drawing and it would be expected that the area of the slide valve engine ports would be larger than in the engines where the length of the ports is small. Whether they are made larger or smaller depends very much upon the type of valve gear employed and the humor of the designer.—[Ed.]

Gas vs. Steam Engine.

EDITOR THE PRACTICAL ENGINEER:

Please inform me which is the more economical way to run a 50 horse power plant: with a steam engine and boiler or with a gas engine and how much fuel of each kind is required to furnish each kind of engine for a 12 hours' run? Which will be the cheaper on a 10 years' run, considering all repairs and labor?

Bethlehem, Pa. B. O. G.

These questions at the present time are stirring up the engineering world, since it is a very difficult thing to say which is the more economical—the gas engine or the steam engine. However, it might be said that when power is needed only for a short time, and where no steam is required for heating, the gas engine should be the more economical; but in places where steam is necessary for heating and other purposes, the steam engine will usually show the greatest economy. The question of fuel consumption is also a variable one, and depends upon the kind of engine used and the conditions. For a 50 horse power steam plant, about 5 pounds of coal per horse power per hour would be a fair value, so that if the 50 horse power engine ran 10 hours, it would require about 2500 pounds of coal during that time, or something over a ton. It could, however, easily run up to two tons. A fairly economical gas

engine uses about 30 cubic feet of gas per horse power per hour, so that a 50 horse power engine would require 1500 cubic feet of gas per hour, or 15,000 cubic feet for the 10 hours. In reference to the wear and tear and labor required, it is very probable that the gas engine would show the best results, because with the gas engine, no fireman is needed and no repairs are, of course, necessary on the boiler. In conclusion, it may be said that whether a steam engine or gas engine should be installed in any plant depends entirely upon conditions, and very often upon the humor of the proprietor.—[Ed.]

Emptying Tank with Different Lengths of Pipe.

EDITOR THE PRACTICAL ENGINEER:

If a tank of water had seven 2½-inch pipes running from the bottom, ranging in length from 10 feet to 70 feet, which one would empty the tank the quickest?

Mingo Junc., Ohio. D. J.

The longest pipe would empty the tank the quickest since the head of water on the orifice of the pipe 70 feet long is the greatest.—[Ed.]

Resistance of Wire.

EDITOR THE PRACTICAL ENGINEER:

Kindly explain to me in your next issue how to increase the Ohms of a 1000 Ohm magneto bell; also how to measure the Ohms of it.

Detroit, Mich. W. J. B.

The Ohms can be increased by adding more wire to the magnet. The Ohm is the unit of resistance and it can be measured accurately by either the Wheatstone bridge method or by the application of Ohm's law. It can be measured approximately by finding the length of wire and its size and by referring to a wiring table which gives the resistance of different size wires for certain length, its resistance in Ohms can be found.—[Ed.]

Setting Slide Valve.

EDITOR THE PRACTICAL ENGINEER:

I am a young man just taking a position as a hoisting engineer and I can't get the slide valve on my engine right. When I get ⅛-inch lead on the back centre, I get ½-inch lead on the front centre and I think it ought to have as much lead on one side as on the other. I would like to know how to find this. No matter how I set the eccentric I always get more lead on one side than on the other.

French Village, Ill. W. M.

If the design of the valve is correct, this can be remedied by moving the valve on the valve stem. Put the engine on centre and set the eccentric 90 degrees ahead of the crank. The valve should then be in its mid-position and cover the ports. If it does not do so, then the valve must be moved until it does. The eccentric can then be moved in the direction in which the engine is to travel just enough to give it the required lead. Clamp the eccentric in position and turn the engine around on its other centre and if the valve is designed properly there should be just as much lead at that end. If it does not give the required lead, then the dimensions of the valve must be changed by either giving it more lap or else cutting some off, depending upon what is required.—[Ed.]

Injector vs. Pump for Cold Feed Water.

EDITOR THE PRACTICAL ENGINEER:

I am in charge of two 200 horse power boilers and would like to find out which is the most economical: A pump pumping cold water at a temperature of 40 to 50 degrees or an injector which is supplied with steam at 140 pounds pressure?

Brooklyn, N. Y. C. A.

If the exhaust from the feed pump is not used for any specific purpose, then the injector is very much more economical, because all the steam utilized by it goes toward heating the feed water. It is also better for the boiler to receive the hotter feed.—[Ed.]

A Question from the Hawaiian Islands.

EDITOR THE PRACTICAL ENGINEER:

Please explain through the columns of your paper the following: I am in charge of a pumping plant which consists of two B. & W. boilers and two Blake pumping engines. We have only one feed pump to feed both boilers and it is the Blake patent, single acting. We have more trouble than enough in packing the plunger, for no packing stands 24 hours and we are using the best packing money can buy. I would be very much obliged if you or any of my brother engineers could suggest a way to remedy this trouble.

Ewa, Hawaiian Islands. J. S. P.

There must be something wrong with the pump. The rod must either be scored or the piston rod is out of line or else there is something the matter with the stuffing box. We would be pleased to hear from other engineers about this.—[Ed.]

Cut-Off and Number of Expansions.

EDITOR THE PRACTICAL ENGINEER:

Will you kindly answer me the following question in your Question Department?

In a 12" x 18" engine the clearance is 5 per cent. and cut-off occurs when the piston is 6 inches from the end of its travel. What is the real cut-off and what is the number of expansions by volume?

Cincinnati, Ohio. C. C. R.

The stroke being 18 inches and cut-off taking place 6 inches from the end of the piston gives a cut-off at ⅔-stroke. The number of expansions is obtained by dividing the length of the stroke by the distance the piston has moved when cut-off takes place plus the clearance or in the above problem $18 \div (12 + .05 \times 18) = 18 \div 12.9 = 1.394$ expansions.—[Ed.]

How About This?

EDITOR THE PRACTICAL ENGINEER:

I have a certain number of boilers cut in parallel; also a certain number of engines. The average boiler pressure is 140 pounds gauge.

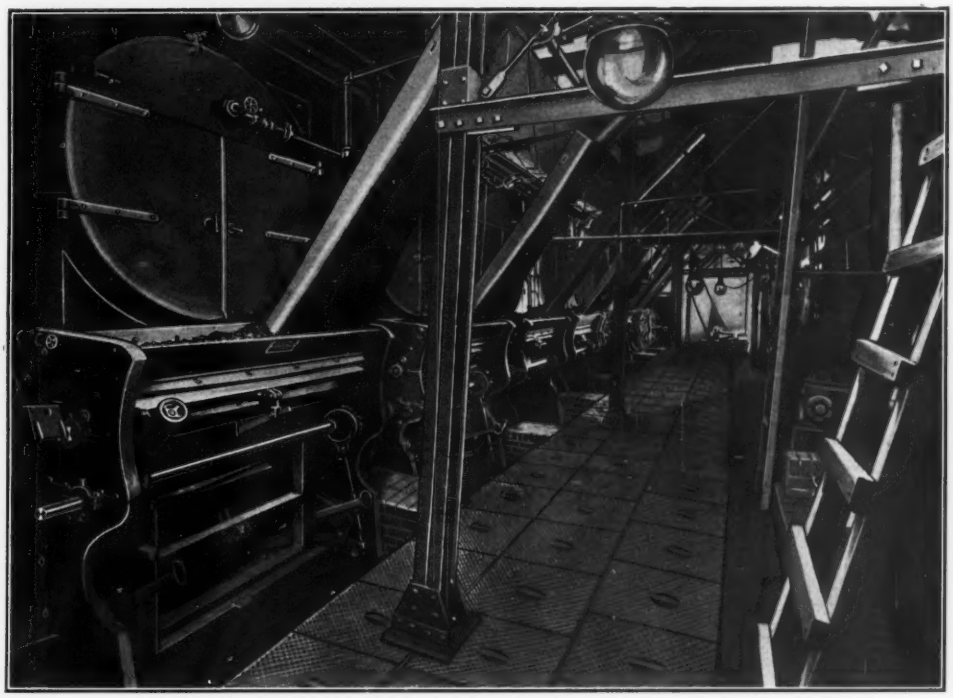
Now, it happens that our firemen can't hold the pressure at 140 pounds but it will drop to 85 or 90 pounds per square inch. At this point they can hold it O. K., with a full load on our engines. At 85 or 90 pounds pressure our engines take steam continuously from one end of stroke to the other. Now, it seems to me that with the pressure 140 pounds and the engines cutting off at a part of the stroke, it would require less steam and consequently it would be easy to hold up steam. How about this?

Marion, Ohio. I. F. W.

The Wetzel Automatic Mechanical Stoker.

There are six essential features which are required of a satisfactory mechanical stoker: Economy, durability, large excess capacity, smokelessness and simplicity of construction and operation. These requirements are demanded by the average boiler plant, since the boilers must often be forced beyond their rated capacity, and at the same time they must show a sufficient net return to warrant their use. The continually increasing price of coal has made the power user turn to cheaper grades of fuel and it is only by some mechanical means that these cheaper grades can be burned economically.

A mechanical stoker which has answered the above requirements is the Wetzel Mechanical Stoker, manufactured by the Wetzel Mechanical Stoker Co., Trenton, New Jersey, and the accompanying illustration shows one of the many boiler rooms in which it has been installed. This particular boiler room shows the stokers applied to 1500 horse power horizontal tubular boilers in one of the plants of the New York and Pennsylvania Co., of New York City, which Company has 12,000 horse power of its boilers equipped with the same device. Among other installations where they are also installed are the plants of the Elks Paper Mills, Johnsonburg, Pa.; Lock Haven Paper Mills, Lock Haven, Pa.; Clarion Paper Mills, Johnsonburg, Pa.; Crocker-Burbank plant, Fitchburg, Mass.; and the Baltimore Refrigerating and Heating Co., Baltimore, Md.



Wetzel Mechanical Stokers applied to 1500 H. P. Tubular Boilers, New York and Pennsylvania Co., New York City

The stoker consists of a cast-iron stoker front, on the outside of which is arranged the coal hopper, driving machanism and regulators. On the inside is a frame upon which the coking grate, main grate and dumping grate are assembled. The largest proportion of air space is provided in the coking grate, less and varying proportions of air space in the main grate and a still smaller proportion of such spaces in the dumping grate. The three grates incline downwardly throughout their entire surface. By such a construction it is a comparatively easy matter to keep the grates covered with fuel or residuum without any attention, the amount of air admitted to the burning fuel from beneath being duly proportioned to the state of its combustion.

In operating the stoker, the coal is fed into the hopper, from which it is automatically pushed to the dead plate and coking grates, where the volatile gases are driven off and mixed with heated air admitted through the perforated tile of the combustion chamber. The coal, after having been coked, travels slowly down the inclined main grate toward the dumping grate, receiving air through the grates to complete the burning process. The speed at which the stoker pushes the coal on the grates can be regulated to conform with the duty required, while the shake of the main grate can be adjusted slower or faster according to the amount of ash in the coal.

The stoker is driven by a small engine at the side and is connected direct to a reducing gear, which reduces the main stoker shaft to 3 revolutions per minute. One engine is usually applied for driving two of the large size stokers but any number can be operated by connecting the main driving shaft together with couplings or by an overhead shaft connected independently to each stoker.

All parts of the stoker are made of heavy material which is distributed to give the maximum strength and durability. The mechanism is outside of the stoker front and entirely removed from the heat of the furnace and the method of supplying the coal to the front of the furnace adds to its long life, as it always remains cool.

A number of tests have been made with soft coal which have shown that its positive feeding for regulating the supply of fuel, the constant stirring of the fire by the motion of the grate-bars, and the arrangement for discharging the ash and

clinker from the dumping grate without disturbing the process of combustion, can be accomplished with the maximum economy and capacity, with the least expenditure of labor. This necessarily means a uniformly clean fire over the entire grates and the absence of all smoke.

To attain the complete combustion of the volatile matter in the fuel and the prevention of smoke, a coking arch of firebrick is sprung across the furnace. This covers the upper part of the grate and forms a reverberatory furnace and gas producer whose action is to coke the fresh fuel as it enters and releases its gases. These gases are mingled with the heated air supplied through the special perforated tile above the dead-plate and are quickly consumed in the large combustion chamber above the bed of incandescent coke on the lower part of the grate, which arrangement makes it unnecessary to use a steam jet or other devices. The necessary requirements for smokeless combustion are therefore met with.

The Lunkenheimer Generator Valve.

An improved form of generator valve has lately been placed on the market which embodies a number of desirable and important features. The sectional view herewith illustrates the construction of the valve. One of its principal features is the regulation of the spring which holds the disc to its seat. This regulation can be accomplished while the engine is running, and without in any way interfering with the proper operation of the valve, it only being necessary to loosen the thumb nut F, when the sleeve G can be screwed up or down to loosen or tighten the tension of the spring, after which the thumb nut F is again tightened.

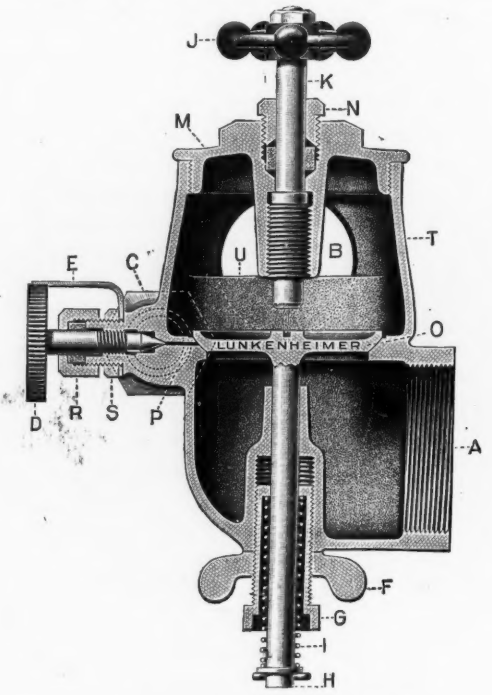
It has been found that gasoline engines work best with the generator valve disc spring set at some particular tension; but as this particular tension cannot be ascertained except by trial, when the engine is in operation, it is necessary that provision be made for the easy adjustment of the spring while the engine is running, which feature will be found in this form of generator valve. The lift of the disc, and consequently the speed of the engine, is regulated by means of the stem K operated by wheel J.

Another feature in the design of the valve is the light but strong construction of the disc. The seat opening is large so that the area is considerably in excess of that of the inlet A. This avoids wear on the seat and the breaking of the disc, as the disc does not have to be raised very far off its seat to permit a full charge of air and gasoline to enter the cylinder. The movement of the disc being but a trifle, the shocks caused by seating are reduced to a minimum. The disc can be reground when worn by removing the cap M, and inserting a screw-driver or other flat instrument in the slot in the top of the disc provided therefor.

The valves are made of bronze composition, and the metal is so distributed about the valve, that those parts subjected to the greatest strain are made heavier in proportion. Owing to the oxydizing effect of gasoline on iron or steel, these materials are entirely eliminated.

The supply of the gasoline is controlled by the needle valve D, and the end of same is placed as near as possible to the outlet of the gasoline into the valve, very little clearance being allowed. The result is that the gasoline is injected in the form of a spray, thus vaporizing thoroughly with the air admitted through the air inlet A. This needle valve has a long taper bearing and the threads on the stem are of fine pitch, thus very close adjustment can be secured and the amount of gasoline injected can be regulated to a very fine degree.

The wheel handle D is engraved with numbers to show the different degrees of opening. This wheel handle has a flat



Lunkenheimer Generator Valve

spot on its periphery with which the spring E engages. The object of this is to enable the operator, after he has properly adjusted the needle valve for the correct mixture, at any time to easily obtain this same adjustment should he close the needle valve or open same beyond the proper setting. No matter where this flat spot may be, after the needle valve has been set, the spring E can be brought to bear on same by merely loosening the lock-nut S, which will permit of the free turning of the spring. The union C is provided on the gasoline inlet to facilitate its connection.

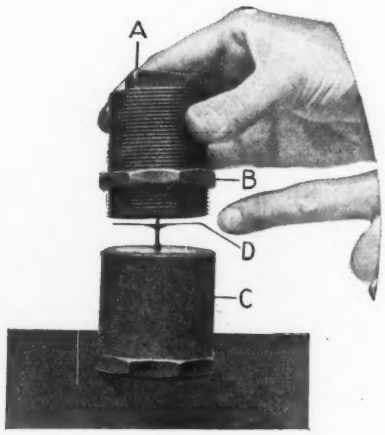
This generator valve is the result of considerable experimenting on the part of the Lunkenheimer Company,Cincinnati, Ohio, from whom further information can be obtained.

There are two factors that affect the capacity of a chimney: its cross-sectional area and its height. The intensity or force of draft is proportional to the square root of the height of the chimney and, for a given height, the capacity is directly proportional to its cross-sectional area within certain limits.

The induction motor is one of the simplest devices which is used for the conversion of electric energy into mechanical energy; its simplicity of construction, the absence of parts requiring frequent attention, and its self-contained construction make it a type of motor especially adapted to conditions requiring constant and severe service.

The Philadelphia Grease Cup.

The rapid increase in the use of grease for all purposes has caused a demand for a grease cup which combines simplicity, reliability, ease of regulation and a positive action. The Philadelphia Grease Cup, shown in the accompanying illustration, has been designed to meet these requirements. It differs from the usual make of grease cups inasmuch as it uses compressed air for the feeding force instead of spring compression,



The Philadelphia Grease Cup

whereby it is claimed that any possibility of the grease hardening in the cup is prevented, together with its attendant danger of hot journals through lack of lubricant at the critical moment. It is also claimed that it automatically meets any emergency by supplying an increased amount of grease at the very moment the journal calls for it, without requiring special attention from the engineer, and at the same time feeds a grease of any density that is desired.

The cup consists of five parts, the upper part A, being threaded externally to screw into the body C, the lock nut B, the diaphram D and a funnel inside of C not shown in the cut. The object of the diaphram D, which is a floating piston stamped from thin metal, is to keep the level of the grease in the cup without exerting any pressure thereon other than its own weight. It is so connected that it moves without friction and turns when A is turned.

The funnel in the bottom of cup C has a large direct opening which draws the grease by an easy incline to the centre, thus insuring a steady feed. It also acts as a reserve after the part A has been screwed down its full length, in which case the part D rests against the funnel. Should this happen, the grease which is fed by pressure is that around the funnel, which reaches the central outlet through small holes near the bottom of the funnel, while within the funnel is a surplus of grease that cannot be fed out by pressure. This remaining grease must be drawn out either by gravity or by heat, or a combination of both; the object being that if from any cause the cup cannot be at once refilled, the surplus grease in the funnel will be amply sufficient to properly lubricate the journal until the refilling is done.

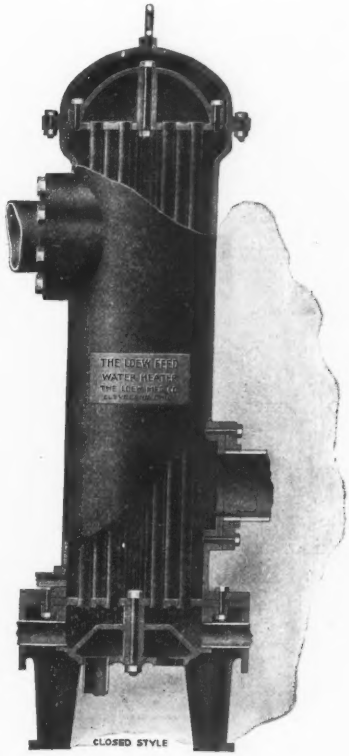
The cup is screwed into place in the usual manner and when it requires filling, A is unscrewed and removed and C filled even full with grease. Insert A again, making sure that the floating piston D hangs a trifle below its lower edge, and screw down not to exceed one-quarter of its length and fasten with the lock-nut B. This will suffice for a run of from one week to a month, depending upon the nature of the place and the condition of the journal. Thereafter, one turn of A every day or two, or two or three or four turns once a week will be sufficient; in either case the result being the same.

No regulator or indicator is used in this cup because none is needed. The pressure in the cup, being formed by compressed air, is never exhausted and although part A may not be turned down quite so often as might be thought necessary, it is impossible for the journal to be harmed. Should heat generate, it will follow up the funnel in the cup, thus making a warm incline down which the grease will slip easier, while the same heat will expand the air behind the grease more. This makes a combination that automatically provides an increased amount of grease to the journal at the right moment, without requiring the engineer's special attention.

The cups are made in brass and iron in all sizes. For further information, address the Philadelphia Lubricator and Manufacturing Co., Inc., 1525 Land Title Bldg., Phila., Pa.

The Loew Feed Water Heater.

When water is heated in a tube, it is a well-known fact that the centre, or core, will not heat so rapidly as the outer surface of the water. To overcome this difficulty the Loew feed water heater, shown in the acocmpanying illustration, was designed and it is so constructed that when the water traveling



The Loew Feed Water Heater

through the tube reaches the several ports at the top and bottom of the various sections of tubes, the course of the water is entirely changed, which alters its relative position and thor-

oughly mixes it, whereby the temperature is equalized.

The heater is so arranged that the water passes six times through the exhaust steam and the several ports which mix and equalize the temperature of the feed water; also render fittings entirely unnecessary and therefore none are used. By this arrangement, therefore, it is claimed that the highest possible amount of heat units are given to the feed water with the minimum amount of friction.

The cold water enters section 1 through the water inlet and is carried up to the double port at the top of the heater, where its course is entirely changed and the water mixed, accomplishing the first equalization of the temperature. It then passes down the tubes, section 2, through a cored passage to the port at the bottom, which repeats the equalizing of the temperature, and traveling up section 3, it reaches a double port at the top, which again mixes it; continuing down tubes section 4, it reaches another port, which repeats the mixing of the heating water and it travels in tubes, section 5, to a final double port, where the temperature of the water is thoroughly equalized and then down through tubes, section 6, to the outlet. The cold water is received on one side and the hot water discharged on the opposite side, but the distribution of the ports is so arranged that the expansion is perfectly equalized, thus preventing any undue strain.

The heater is built of heavy cast-iron and brass, the outer shell, legs and caps being of cast-iron, the tubes of straight seamless brass; both ends of the tubes are rolled into tube plates, the bottom tube plate being bolted to the casing at the bottom of the heater, making it stationary; the top tube plate is loose and free from the outer shell, so that the tubes have ample room to expand upward when hot.

The heater is provided with hand-hole plates at the bottom that it may be quickly cleaned. The top heads are easily removed and the bottom unbolted and dropped down when an open surface of the tube for cleaning is desired, and the complete cleansing of the heater can be accomplished in a very short time.

For further information, address the manufacturers, the Loew Supply & Mfg. Co., Cleveland, Ohio.

Book Reviews.

Engineering Practice and Theory, by W. H. Wakeman. Size 5 x 7½. 20 chapters, 185 pages, numerous illustrations and 200 examination questions. Fourth Edition. Published by the author, 64 Henry St., New Haven, Conn. Price, $1.00.

There has been such a growth in the number of steam engineers during the past ten years and the qualifications of what goes toward making a successful engineer have become so rigid that there has been a demand for a book which will not only give the fundamental principles of steam engineering but which will keep the engineer abreast of the times. Mr. Wakeman has endeavored to fill this demand with his book and the fact that it is now in its fourth edition is a proof of its popularity.

The book throughout is written in a clear and lucid style. The duties of an engineer are first taken up, then the description and uses of each piece of mechanism about a boiler, then the indicator and its uses, the method of finding the horse power, compound engines, receivers, triple and quadruple expansion engines, air and circulating pumps, feed pumps and injectors, steam heating and many other subjects.

The last chapter in the book is devoted to 200 examination questions, all of which can be answered by reference to what has been described in the earlier chapters. The book should be especially valuable to young engineers just starting in the business.

Modern Locomotive Engineering, by C. F. Swingle. Size 5 x 6¾. Pocketbook style. Full seal grain leather, with gold edges. 600 pages, 275 illustrations. 20th Century Edition. Published by Frederick J. Drake & Co., 211 E. Madison St., Chicago, Ill.

The aim of the author in compiling this work was to furnish locomotive engineers and firemen such information as will thoroughly equip them for the responsibilities of their calling. The subject matter is arranged in such a manner that the fireman just entering upon his apprenticeship may, by beginning at the first chapter, learn of his duties as a fireman and then the succeeding pages will give him the requisite knowledge pertaining to the construction, maintenance and operation of all types of engines.

Breakdown and what to do in an emergency are given, including engine running and its varied details. The air brake, including all the new and improved devices for the safe handling of trains, is also described. The book is written in plain and explicit language.

Knows a Good Thing When He Sees It.

EDITOR THE PRACTICAL ENGINEER:

I take THE PRACTICAL ENGINEER and consider it the best paper for engineers that I ever saw. I don't understand how it is gotten up in such good shape for 50 cents a year. Every engineer ought to take it at that price. I like the question department and I also think that if any engineer has a "kink" that will help some other brother engineer, he should tell it through the columns of THE PRACTICAL ENGINEER.

Shelburn, Ind. C. A. CROW.

Armature cores which are built up of soft sheet steel punchings or laminations, are treated to reduce hysteresis, and are japanned before assembling, thus insulating them from one another and reducing Foucault current losses.

William Henry Edgar.

It was with sincere regret that we heard of the death of William H. Edgar, president and founder of the Dearborn Drug and Chemical Works, who died suddenly at Hot Springs, Ark., on November 26th.

Mr. Edgar was well known and deservedly popular, especially among engineers. He was a chemist of marked ability and frequently imparted his knowledge by lecturing before many engineering societies. He founded the Dearborn Drug and Chemical Works some eighteen years ago, when he was but twenty-two years of age, and his success is known to every engineer on the Continent. His greatest pride was in the magnificent organization of associates and representatives whom he had gathered around him and by all of these men and his many acquaintances he was dearly beloved.